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OF

CIVIL ENGINEERS

VOLUME 7

1920

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Leonard Metcalf
President, Boston Society of Civil Engineers
1919–1920

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BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PROCEEDINGS

PAPERS IN THIS NUMBER.

Discussion of the "Cost-Plus and Other Forms of Contracts."

Memoirs of deceased members.

MINUTES OF MEETING.

BOSTON, December 17, 1919. — A regular meeting of the Boston Society of Civil Engineers was held this evening at Chipman Hall, Tremont Temple, and was called to order at 7.50 o'clock by the President, Leonard Metcalf.

There were 96 members and visitors present.

The record of the last meeting was read and approved.

The President reported for the Board of Government the election of the following candidates to membership in the grades named:

Member: Carl S. Drake, Frederick A. Lovejoy, John E. L. Monaghan, Howard C. Thomas, Arthur C. Tozzer and Warren D. Trask.

Junior: A. Winton Caird.

The Secretary submitted, for the committees appointed for the purpose, the following memoirs of members of the Society: that of Leslie Peter Reed, prepared by Frank S. Bailey; and that of Charles E. Putnam, prepared by Edward W. Howe. The memoirs were accepted and ordered printed in the JOURNAL of the Society.

The President announced the death of Frederic P. Stearns, a past-president of the Society, which occurred December 1, 1919. The committee selected to prepare a memoir of Mr. Stearns consists of Allen Hazen and X. Henry Goodnough.

The speaker of the evening was Mr. Allen Hazen, who spoke most interestingly on the subject of "Hydraulic Fill Dams." The address was illustrated with lantern slides.

Adjourned.

S. E. TINKHAM, *Secretary.*

APPLICATION FOR MEMBERSHIP.

[January 15, 1920.]

THE By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

PRICE, HERMAN SCOTT, Boston, Mass. (Age 26, b. New York, N. Y.) Attended Cooper Institute of Technology, New York City, received a B.E. degree in civil engineering; 1915 to 1917, employed in constructing substations and high potential transmission lines, with Westchester Lighting Company; 1917–1918, engaged in making scientific investigations of aëronautical instruments for War Department; 1918–1919, with United States Coast and Geodetic Survey. Refers to N. C. Grover, C. H. Pierce, H. B. Wood, M. R. Stackpole.

LIST OF MEMBERS.

ADDITIONS.

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CAIRD, A. WINTON. 316 Huntington Ave., Boston, Mass.
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THORPE, GEORGE H. 60 Prospect St., Hartford, Conn.
WADE, W. NEWELL 26 Albion Road, Wollaston, Mass.

EMPLOYMENT BUREAU.

THE Board of Government maintains an employment bureau for the Society, to be a medium for securing positions for its members and applicants for membership, and also for furnishing employees to members and others desiring men capable of filling responsible positions.

At the Society rooms two lists are kept on file, one of *positions available* and the other of *men available*, giving in each case detailed information in relation thereto.

Men Available.

497. Age 38. Graduate Boston Mechanic Arts High School in 1900. Experience, four years as landscape engineer; three years railroad work; two years as town engineer on municipal engineering; five years engineer of power station and factory maintenance; three years elevated and subway construction, and past two years in U. S. Navy, inspector mechanical equipment, navigating and commanding officer. Desires to return to professional work in the line of consulting civil or mechanical engineering. Salary desired, $3 000 per year.

498. Age 25. Graduate of Worcester Polytechnic Institute. Experience, drafting one year, and two years engineer on dry dock construction. Desires field engineering work. Salary desired, $200 per month.

Vol. VII JANUARY, 1920 No. 1

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PAPERS AND DISCUSSIONS

This Society is not responsible for any statement made or opinion expressed in its publications

DISCUSSION OF "COST-PLUS AND OTHER FORMS OF CONTRACTS."

By C. Frank Allen, Frank W. Hodgdon, Charles R. Gow, Charles M. Spofford, R. A. Hale, E. F. Larned, Leonard Metcalf, Victor H. Clarke, H. E. Wheeler, P. A. Shaw and James W. Rollins.

(Presented November 12, 1919.)

C. Frank Allen.* — What the speaker wishes to say upon this subject is in part stated by him in a publication printed after hearing the paper under discussion, and largely influenced by it. It is as follows:

"This emergency contract was drawn with rare skill and foresight and has proved most successful for the purposes intended. Its primary and direct object was to promote speed. The saving in time, peculiarly in cantonment construction, meant the earlier placing of our soldiers in the trenches, with the saving of lives from shortening the war.

"Forms of contract much used in construction may be classified as: lump sum, unit price, cost plus a fixed sum and cost plus percentage.

"The emergency contract is a modified cost plus percentage system, with a fixed sum as a limit or upset fee as a perfecting feature. The sliding scale adopted tends to act as a deterrent to unnecessarily increasing the costs, while the upset fee makes unprofitable a cost beyond a certain sum. In one structure costing $25 000 000, the upset fee was reached at $10 000 000, and no advantage to the contractor accrued beyond that sum.

* 88 Montview Street, West Roxbury, Mass.; formerly professor of Railroad Engineering, Massachusetts Institute of Technology.

An adequate system of auditing, however, is essential to this form of government contract. Its success has aroused much favorable interest among engineers and contractors.

"It is accepted by engineers that, in the long run, with competitive contracts, the contractor's bid is made high enough to cover all risks in sight, many of which fail to materialize, but for which the owner pays. The owner effects a saving when he is able to assume the risk. If occasionally a contractor's bid is below cost, the contract is more difficult to enforce, and the quality of the work usually suffers in some degree. A cost-plus system removes the risk to the contractor. The owner, however, assumes new risks, — the efficiency of the contractor and an uncertainty as to the final cost.

"Where the conditions are not uncertain, so that the risk is small, and where complete plans are ready at the time the bids are made, and where also costs of materials and of labor are stable, lump-sum contracts will be favored by many engineers and their clients as simple, effective and cheaper. Where the conditions are understood, but the total quantities are not fully determined, the unit-price contract is indicated rather than the lump sum. The lines of demarcation between these two have been reasonably established already and do not need attention here.

"The conditions which dictated a cost-plus system for cantonment and other construction were the need for the utmost speed of execution, including the necessity for starting work before plans could be completed or perhaps even begun; the flexibility which allowed plans to be changed suddenly to meet physical conditions or newly adopted standards; the chance to utilize materials which from time to time proved most available; and the impossibility of knowing in advance the costs of materials and labor under new conditions suddenly created.

"To these were added the possibility of assigning the work promptly to the contractor best qualified to do it, taking into account energy, business responsibility and knowledge of local conditions.

"Furthermore, the private field for contractors' activities was suddenly restricted, and from patriotic instincts contractors stood ready to undertake almost any work, of whatever magnitude, provided only that they were assured against loss. Contracts have thus been completed at a percentage of profit which would not be acceptable in normal, active times.

"In March, 1919, while business is halting previous to the formal signing of the treaty of peace, the costs of labor and materials are so unstable that the value of the cost-plus contracts is abnormally great, for it must be expected that lump-sum bids

will be high to cover possible changes in costs, especially with long time contracts.

"There are some disadvantages in the cost-plus system. Important among these is the fact that workmen will be more insistent upon high wages than on lump-sum work. Who is there to deny it to them? Experience also indicates that they are less alert and interested. Even the contractors are likely to suffer in efficiency if the prod of self-interest is lacking. If a contractor has several contracts, some lump-sum, others cost-plus, which will secure his most active interest and attention? It can hardly be doubted that a lump-sum system tends to secure a larger measure of efficiency of labor than does a cost-plus system.

"A serious criticism of the cost-plus system in emergency contracts has been that each contractor, in his zeal to speed up his work, competed disastrously with other contractors. The instability of prices, foreordained no doubt, was accentuated through the cost-plus contract.

"Municipal, state and government work demand competitive bidding. This is to diminish or prevent abuses growing out of political favoritism. Non-competitive cost-plus contracts are thus legally inadmissible. Furthermore, any system of cost keeping and auditing tends to be expensive, and unusual opportunities are opened for corrupting members of the cost-keeping force, who in some cases might even be appointed with sinister intent.

"It is possible, probably, to introduce into the cost-plus system competitive features sufficient to comply with the legal requirements of statutes or ordinances. Let the chief engineer prepare a careful estimate of cost, with the assistance of reliable contractors if he prefers. Submit the work to competitive bids, the contractor bidding upon the percentage of cost for which he undertakes the work; add a provision that the upset or maximum fee shall be restricted to the percentage bid applied to the chief engineer's estimate already prepared and stated in the proposal, or use a cost-plus fixed sum system and bid competitively on the fixed sum.

"Important objections are that no measure is secured of the efficiency of the contractor, and that the ultimate cost of the work is problematical. Add to this the difficulties inherent to auditing. If the work is not to be let to the lowest responsible bidder, opportunity for political favoritism is provided. There are doubtless cases, however, where the advantages of this method would outweigh the disadvantages in municipal work.

"It is reasonable to assume that the lump-sum and the unit-price systems will continue in use; that the cost-plus system will be found to have much value in private contracts; and that

in time engineers will develop a wise judgment as to the use to be made of each of the three systems."

Beyond what is stated above, the present speaker desires to add a discussion prepared for this meeting before referring to the material quoted above, and which does not materially repeat or interfere with it.

The cost-plus system undoubtedly has great value. It, no doubt, will have greater use in future than it has had in the past; the conditions created by the war led to a very extensive use of this form of contract. Because it was very successful in many cases under the conditions existing, it does not follow that under different conditions it should be considered as a panacea for all evils which have existed in contract letting.

The cost-plus contract is specially adapted to a rush job. The contractor, if he is keen, is interested more in his profit for the year than in his profit for a single job. Very many of the war contracts were large contracts, and the contractor was insured of as large a profit as would under other systems ordinarily fall to his lot for the same length of time; generally larger. Whether we, as engineers, have always thought so or not, many contractors are human in the best sense, and were as ready as the "dollar-per-year" men to help win the war. No doubt there were other contractors sensitive mainly to the profit, but these did not positively secure the success of the system, for success must be admitted.

There were features of the cost-plus contract which were not commendable. Under the conditions of war work, the efficient small contractor was largely eliminated, — necessarily perhaps. The tendency was towards centralization in large concerns which kept the work within their own organizations, without subletting.

Again, how much was the difficulty of high wages accelerated by this system, which caused contractors, under the conditions, to pay whatever was necessary to secure the results, which it was their unquestioned duty to secure? It is unfortunate that such a necessity existed. Yet the work was done, and the war more promptly ended in victory, rather than in defeat or carnage long drawn out.

One of the good results from the use of this system (under conditions existing) has been that the engineers and contractors have found it easy to realize that they were working together for a common end: and distrust largely vanished. This gain ought never to be altogether lost. The conditions, however, were responsible for this good result to a greater extent, probably, than was the form of contract.

In the long run, the nature of the engineer and the nature of the contractor will not be revolutionized by changing the form of contract. The possibility of squabbles is not eliminated by it. If the contractor takes work in expectation of speedy completion, and delays occur, he is in reality aggrieved.

If work is added which is not "extra work" properly within the contract, but outside of the contract, will the contractor be expected to do this within his upset contract profit? The opportunity for a lawsuit is not eliminated. If material is furnished from a distance, and the engineer says it is unsatisfactory, who stands the loss? Has the contractor bought the material judiciously, or from his best friend?

If the engineer wants to "skin" the contractor, or if the contractor and his friends are grafters, will the form of contract make it impossible to wrong one side or the other?

What is to be done in our larger municipalities, where laws have seemed necessary to prevent graft in awarding contracts, if a cost-plus system is adopted? Shall competitive bidding go by the board? What will competitive bidding mean if no restriction is placed upon the final upset price?

It is the opinion of the speaker that where plans can be fully completed in advance, so that the work is definite, and in times where labor and material prices are reasonably stable, and no special elements of risk are present other than the weather, a lump-sum contract will often prove more satisfactory to both contractor and owner. This would apply somewhat definitely to mill buildings or factories.

Where the quality of material is well known but the exact amount less certain, and where no special elements of risk exist, a unit-price system is indicated, and will probably be more satisfactory to contractor and owner. Laying water pipes, building

sewers or reservoirs, grading, are specific examples. In each of these cases the owner knows, within reasonable limits, the cost before starting work.

Wherever, in connection with the lump-sum or the unit-price cases referred to above, there are serious elements of risk, as in the foundations of a mill, or where there is a probability of quicksand in an excavation, or any other serious element of risk, it may often be wise to let a limited part of work on the cost-plus basis, while the greater part of the construction is let either as lump-sum or unit-price, in substantial harmony with previous practice in work of a similar sort. In the immediate present, when labor and material costs are altogether uncertain, the argument for the cost-plus system is usually strong and in many cases convincing.

To the contrary, in small contracts the cost of auditing, and its inconvenience, constitute a strong argument against the cost-plus system. There are many private contracts let to-day, however, on the cost-plus basis, where no attempt is made to audit accounts, because the contractor is well known and entirely trusted; the contract is let, not under wide competition, but to contractors of reputation who value their reputation.

It is the opinion of the writer that, as sure as conditions become stabilized, the majority of contracts will be largely let under lump-sum or unit-price systems as heretofore, but that the cost-plus system will have a considerably increased use, partly for the whole contract, but also for parts of contracts where the risk ought not to be borne by the contractor.

The inquiry seems to be pertinent, Will the cost-plus system increase or decrease the cost of the work, not its price? The cost in its final analysis is a labor cost. The cost of labor will be increased at least by auditing costs, and it is probable that the efficiency of labor will be less under the cost-plus system.

In the speaker's experience, laborers were known to work with greater vigor as the contractor hove in sight. From that cause, contractors did simple work more cheaply than the city forces doing similar work. The question, whether under present conditions the average laborer will work with special vigor under any circumstances, appears to interfere slightly with the above prognosis.

I couldn't help thinking that the contract which Colonel Gow had to deal with was a contract which illustrated the cost-plus basis to the very best advantage. I am not sufficiently familiar with the contractor to be sure about it, but I assume that the contract, in the profit that it yielded to him, was a contract rather better than he had previously had. That tended to make things run smoothly. The matter of patriotism, I take it, was not altogether lacking in that contract. The powerful arm of the Government, in the regulating of matters which would easily admit of dispute, was another element. Aside from that, I believe that even disregarding the personality of the Government official in charge, his experience as an engineer and contractor, both, made it more possible to bring about results without confusion, and more satisfactorily to everybody, than would ordinarily result in a contract of that sort. I say that came about aside from the matter of personality, which certainly ought not to be neglected.

The editor of the *Railroad Gazette* once stated that one of the advantages of an engineer's education was that it enabled him to look facts in the face. It is very pleasant to hear people pass bouquets to engineers with relation to the fees they collect, and somehow one gets the idea that the engineer is a pretty good fellow; until you strike the fact that he has connection with contractors in enforcing contracts. As it has been suggested that engineers use a cost-plus system in the fees that they charge their clients, let's look the facts in the face. There has never, so far as I know, been any necessity for the passage of laws regulating that feature, but in nearly every municipality there has been found the necessity for laws regulating the letting of contracts for municipal work, and we all know that there have been plenty of abuses, and the case of the engineer, who, I think, has as good a reputation on the average as even the judges, is not to be confounded with the case of the contractor who is dealing with municipalities which have become very corrupt. I think that no one will take issue with me as to the fact that in Boston there have, at times, been serious abuses in contract letting. While there has been some disagreement of opinion, especially as to the arbitration clause, yet, with relation

to the general point of view advanced, as to the attitude of the courts, as evidenced by the Brooklyn dry-dock case, I believe there are other cases quite as substantial, in quite the same direction, and I don't quite see how I can get up an argument on this point, although it may seem that I ought to.

I believe that is the attitude the contractor absolutely should take. I didn't intend my remarks to indicate that contractors are a set of rascals. My experience is to the contrary. I have had to administer work where the difficulties were very serious and where the contractor apparently was not anxious to do the work to my satisfaction; but, take it in the large, you make a great mistake if you assume that the contractor is otherwise than a good square fellow. With a very large percentage you will find he is all right if you treat him right, but it certainly is the contractor's duty to know his engineer, and bid on his work or refuse to bid on his work, as some contractors do, if the engineer happens to be a man of whom they don't approve. In all private work the engineer or owner ought to have the same privilege — and does in private work generally — of excluding or refusing contractors of whom he doesn't approve.

Frank W. Hodgdon.* — I personally have had but little experience with the cost-plus system, other than extra work under contract. The greatest trouble I have found in that scheme is to determine what are costs. The labor costs, and costs of materials which you can purchase, are readily determined. A part of my work has been such that a very considerable if not the larger part of the costs has been plant rentals, and when we come to plant rentals — for plant so large and expensive that it is impracticable to purchase it for the job and sell it at its termination, such as dredges, scows, locomotives, steam shovels, etc. — we've got a very wide question to determine in the matter of costs. These rentals have been the greatest stumbling-block that I have seen in this cost-plus contract. I believe that the unit price is about as good a method of contract as you can get when things are in fairly stable condition. Of course, in recent years it has been very difficult to get any real

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costs either for labor or materials, in advance, which would last for the duration of the contract, and for that reason the cost-plus system, modified as it has been by the Government, seems to me to be a very good way of carrying on the work — practically the only way that was reasonable and fair to the contractor. But when it comes to reasonably settled conditions with the class of work I have been acquainted with, plant rentals are a big stumbling-block for any cost-plus work.

Speaking about the question of arbitration and increased cost to the contractor, — I have had a number of cases of contracts on the unit-price and lump-sum basis, where the contractor, although not a gambler, has bid an apparently very low price and got the job. In such cases the contractor is an intelligent man with a scheme in his head by which he thinks that he can do a certain portion of the work with half the amount or in a much shorter length of time than others, and he goes ahead and uses his scheme and makes a good thing of it. Now, if you are going to arbitrate the losses you must arbitrate the gains, and reduce the cost of the contract by the price of his brains in changing the method. The great desirability of the unit-price or lump-sum contract is that the contractor can use his brains, and he can make money where another fellow might lose. I had a case just come up where a certain work was bid upon by three parties at practically the same prices. The fourth party said that the prices were perfectly proper ones but that he had a scheme by which he could do the work cheaper — at about three quarters of their prices; that he could do it his way and make money — and I think he can, from what he told me.

Charles R. Gow.* — I expressed about all that I had to say on this subject at a previous meeting, but some additional thoughts have occurred to me in the light of what Mr. Allen and Mr. Hodgdon have just said.

The question of cost of necessary accounting work has been raised a great many times by various parties interested in this subject, and it seems to me to be readily settled by the consideration that the accounting has to be done and paid for by some one in any event. If the owner doesn't do it, the con-

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tractor must; and in that event it is presumably charged as part of the contractor's price for doing the work. For those owners not having an accounting force available in their own organization, it would seem to be an entirely simple matter to turn the work over to properly qualified certified public accountants, who would render the necessary reports to the owner. By such a method the accounting work could properly be done as cheaply, or more so, as if included by the contractor under his lump-sum bid, and would give to the owner all the protection as to this feature which he requires.

The suggestion made by Professor Allen, that it would be very difficult for a contractor to carry on both types of work — that is, the lump-sum form and the cost-plus form — at the same time, is a pertinent criticism, and it seems to me to resolve itself down to this, — that no contractor should attempt to carry on both classes of contract work at the same time, because it is obvious that as human nature is at present constituted, — and contractors are human, — if he had both types of work in progress simultaneously there would exist a strong incentive to give consideration in economic questions, to the lump-sum contract, on which he had most to gain thereby; and I should certainly agree that if the cost-plus-a-fee contract is to become at all general, it must be taken up as an exclusive form of contract by certain contracting concerns, otherwise difficulties will probably result, as pointed out.

The possibility of applying the cost-plus form of contract to public work presents an extremely difficult problem, because the same spirit of disinterestedness in the selection of the contractor and in awarding the contract, which exists in the case of a private owner, is often lacking in such cases; it would seem that a special or modified form of cost-plus contract, if any, would have to be worked out, to apply to contracts of a public nature. Very few reputable public officials will wish to be burdened with the responsibility of picking out a contractor for a given piece of work, because criticism and unkind allegations are almost sure to follow, regardless of their honesty of intent. Nevertheless, it is possible such a form of contract might be modified so as to permit of its application even to work of this

character if drawn on a basis whereby the contractors bid on the estimated cost of the proposed work and also the fee which they would be willing to accept, thus maintaining the competitive features. However, such a course would open the door to the incompetent bidder with his low proposal, which could not easily be rejected without assuming danger of criticism.

The question of the contractor's incentive to do his best work under the cost-plus basis seems to me to revolve itself down entirely to the personality of the contractor. The benefit, it has seemed to me, to the owner — or perhaps I should say, the portion of the benefit — would come from availing himself of a contracting concern which has an established reputation, and the establishing of that reputation is bound to be an incentive to the contractor. In other words, as I think I pointed out last summer in a previous discussion on this subject, the average contractor as well as owner will have to undergo an entire change of viewpoint with respect to their responsibilities under the new form of contract. The contractor must be brought to realize that to be successful he must prove to the owner his capabilities, both as a contractor and as an economist, and if he fails in either one of these requirements he lessens his chance of securing additional work. I believe this is the basis of the present operation of a great many concerns that are following the cost-plus method of doing work exclusively. That is, they are attempting to build up a reputation for economy, for speed and progress and general aptitude for their class of work, and they are succeeding admirably in a great many cases, to such extent that owners are now soliciting them instead of as formerly when the contractor was obliged to solicit the owner. That is the only incentive, but it is a strong one; and if some such inducement to effort does not exist we may as well drop all further consideration of this form of contract.

The possible status of small and untried contracting concerns under the proposed form of contract procedure undoubtedly does demand some consideration. Whether the more or less general adoption of the cost-plus-a-fee contract will result in squeezing out and eliminating the small contractors who might otherwise be competent is a question. It seems to me that that

will ultimately be taken care of by their utilization as subcontractors, until such time as they in turn establish a reputation which will warrant their receiving consideration as general contractors.

The apprehension of Professor Allen that laborers be more apt to demand increases in wages under this type of contract is not necessarily well founded. During the war wages were fixed for Government work by a labor board with headquarters at Washington, D. C., and they were changed only after presentation of the very strongest evidence that the prevailing rate for similar trades in the neighborhood where the work was being done, had been increased. In other words, it was impossible to obtain an increase in any labor wage until the demand had been passed upon by this war board appointed by the President and charged with the duty of compiling rates of the various classes of labor in any community, and only such rates as were approved by this board could be paid. The notion, more or less broadcast, that excessive rates were paid, is due to the fact that on account of the rush conditions very long shifts were necessary, and where union conditions prevailed the requirements of the unions as to payment for overtime often made the weekly pay appear unreasonably large. For example, when the work was carried on seven days a week, including holidays, Saturdays and Sundays, and the like, at the prevailing union scale, a very high average rate results. The scale of hourly rates paid, however, did not vary from local standards.

The difficulties foreseen by Professor Allen with regard to possible variation in the amount of work to be done and adjustments therefor, was not a serious obstacle in the carrying on of Government work, because the contract specifically provided that the contractor's employment under the contract covered all of the work to be done on the given project, regardless of how much or how little, — and he was paid on a sliding scale in proportion to the amount actually done. If he did more than originally anticipated he received more, and if less, he received less; but as this amount increased the percentage decreased, and the fixed maximum fee was not affected.

Mr. Hodgdon has put his finger on one of the difficulties

encountered, and that is the question of plant rental. It is a very troublesome and perplexing feature of the cost-plus contract, and one that gave us considerable concern in the prosecution of the Army Base work. A price list was established in this contract which was intended to cover every class of equipment which might be used, and a range of prices was fixed covering the probable scale of rates at which the particular equipment could be hired. Nevertheless, difficulties were inevitable, and so a certain loophole was left in the contract, whereby the contracting officer could vary from the scale, if necessary, — and it was necessary in many instances. Very often a certain type of equipment which was badly needed was not obtainable except at higher rates than those allowed, and the law of supply and demand had, therefore, to govern. If the owner of the needed equipment could obtain a higher rental somewhere else, naturally he preferred not to let it to the Government for less. After equipment was rented, the further question arose as to repair and upkeep. We made it a practice to inspect each piece of equipment when it arrived on the work, and determine whether or not it was in satisfactory working condition. If reported not in such condition, instructions were given that it should be put in satisfactory condition by the owner, before being put to work. Occasionally defects would not become apparent until the machinery was in use, and frequently repairs amounting almost to complete rebuilding were necessary if it were to be continued at work. Oftentimes further repair work was necessary, returning equipment in a condition satisfactory to its owner. However, I believe that this feature is not necessarily a vital one, as affecting the character of the contract, because it can be modified and presumably improved by requiring that the upkeep or replacement repairs on the equipment shall be borne entirely by the owner, in which case, of course, he would be entitled to a higher rate of rental than if the user paid for repairs.

I wish to make myself entirely clear as to my attitude toward this type of contract. From the experience which we had at the Army Base, I was very much pleased with its apparent adaptability not only to that work but to any work which needed to be done in a hurry and where time could be saved by avoiding

the usual preliminaries that require a considerable period of preparation. I was also gratified with the attitude of the contractors, once they had entered into the spirit of the thing. It made me feel optimistic with regard to the possibility of applying it more or less generally, because I think that the average owner will agree that there is no reason why he should pay either excessive prices for the work to be done or why he should get it done at a ridiculously low price. In other words, the result of the effort is for the benefit of the owner, and as a basic principle it seems that he should be willing to pay the fair cost of the work, whatever that may be. Under this form of contract, if carefully carried out by both parties, he does pay the fair cost and no more. He pays for all the uncertainties, as it seems to me he properly should. Under the lump-sum basis the owner, generally speaking, attempts to settle all uncertainties on the contractor. I do not mean to say that this practice in itself is unfair, because the lump-sum contractor accepts the burden knowing it to exist, but it does not seem to me on sound business principles it is just that the unknown quantities and responsibilities should be placed upon the party who does not benefit therefrom, except as he may be a shrewd guesser or, as some might say, a clever gambler. Under the cost-plus system, uncertainties are placed where they properly belong.

From the standpoint of personal interest, I shall regret seeing the general adoption of the cost-plus form of contract, but, nevertheless, I feel convinced that the tendency during the next few years is going to be largely toward its adoption by private owners. Whether or not it can be modified so as to apply to public work I am not at all certain, and if it is, it must be in some modified form that will eliminate the danger, let us say, of suspicious accusation. I believe if I were a public official I should hesitate a long time to apply the cost-plus principle to public contracts without some safeguarding modifications which would eliminate the danger of allegations of favoritism or dishonest intent.

One or two additional thoughts have occurred to me in the light of what the various speakers have said to-night. One is with regard to the owner's position under the lump-sum form of

contract. I think the chief advantage claimed for the lump-sum form is the fact that the owner is confronted with more or less of a certainty as to what the work is going to cost, as against the uncertainty of the cost-plus contract. I do not feel that this is a specially valid argument from the fact that the owner under the lump-sum form does not know what his final cost is to be until after all possible claims and litigation are settled, and he may often be very much shocked by the results.

Professor Allen possibly will not agree in all respects with what I am going to say with regard to the legal aspects of contracts, but I believe the tendency of the courts to-day is toward a broader view in equity, of the contractural relations. A recent decision of the United States Supreme Court, for example, is the case of the Brooklyn Dry-dock, which was quoted at more or less length about a year ago, in the engineering press, which seems to establish the principle that, in case of disclaimer by the owner for responsibility for certain unknown conditions and his attempt to place the burden of the investigation upon the contractor, in making his bid, there are certain responsibilities which he cannot so evade. In this particular instance a sewer which required relocation collapsed in a storm, and flooded the excavation. It developed upon investigation that the outlet sewer, into which this particular sewer emptied, was partially obstructed by the presence of a brick bulkhead, apparently unknown to either party up to that time. The contractor served notice on the owner — the United States Government — that he must remove the bulkhead, repair the sewer and take measures to make it safe against a similar accident, or he would refuse to go on with the work. The Government denied his claim, and he abandoned the work. The determination of the Supreme Court was to the effect that these sewers were all upon the owner's property; that he either knew or had a right to know of the existence of the obstruction in the sewer, and such being the case he could not pass the burden on to the contractor. An accounting was allowed the contractor for the work he had done up to that time, with a reasonable profit.

There have been a number of similar instances. Recently, in this city, conditions proved to be different from those shown

on a plan of borings, and it was found that the responsibility for the misinformation was occasioned by the mistaken judgment of the engineer in making certain notations on the plan. In this case the Master who sat upon the case for the United States Court ruled that the contractor was entitled to damages, not for additional expense but for the additional amount he would presumably have bid had the true conditions been properly shown on the plans.

All of this goes to show that the lump-sum bid does not necessarily imply certainty as to the ultimate cost of the work.

It has been the practice in the past for engineers to take engineering work at times on a lump-sum basis, although I believe now, by general agreement as to the propriety of the case, it is almost universally awarded on some other basis which approximates the cost-plus method, or at least where the uncertainties of the work are not carried by the engineer. No one, I think, will question the justice of that form of arrangement, and no one thinks because the engineer is reimbursed by the cost-plus percentage he necessarily takes occasion to load the job down with unnecessary elements of design or a superabundance of men; and there is no reason, in my judgment, why the same situation could not prevail with regard to contractors. It would simply mean the conversion of the contractor from his previous point of view to the new one, which is that he no longer acts in an independent capacity entirely for his own benefit, but that he is engaged as an expert agent of the owner and that the benefit which he brings to the owner will measure his value as a contractor.

Because lump-sum contracts are so overburdened as they are to-day, with what seems to be unfair requirements and limitations, there is a moral question raised as to the proper responsibility of the contractor always to carry the expense of entirely unforeseen conditions. It has been suggested that the contractor should have recourse to some court of arbitration to determine whether or not the particular difficulty or issue is a matter which the contractor should have foreseen and properly taken into account in making his bid. A practice has been common for some years, particularly among engineers in private practice, who

from time to time may have had unfortunate experiences growing out of loopholes unintentionally left in a contract, to plug such holes by the introduction of an additional provision, usually of a blanket nature, which will prevent any similar recurrence. Having thus specifically provided against any claim along those general lines, the engineer is precluded from listening to any complaint of the contractor, since to do so would be to set aside a specific clause in the contract. In this manner the scrupulous contractor may often suffer from the previous acts of the less scrupulous one, whose acts caused the original insertion of the drastic clause.

David Harum, I believe, said it was a good thing for a dog to have some fleas, as otherwise he wouldn't know he was a dog. So if the contractor does not suffer losses sometimes, he will not realize he is a contractor. He does not ask to have his fair losses arbitrated, but he does ask to obtain relief from these onerous clauses which are intended to prevent unscrupulous action, but should not operate against the worthy and honest contractor.

Charles M. Spofford.* — Previous speakers have stated that the character of the work to be done is of importance in determining the availability of a cost-plus form of contract, and that the cost-plus contract, as generally used, is not one that is ordinarily applicable to the construction of public works owing to the absence of competitive features in such a contract. On the other hand, in the case of emergency construction work, such as the recent war projects of the Government, the cost-plus contract is especially appropriate as it permits the immediate commencement of construction.

There is another element in the character of work which has not been pointed out this evening but which has an important bearing upon the form of contract to be adopted, that is, the necessity of the work. For example, it may happen that a railroad must replace a bridge regardless of its cost in order to maintain service. Under such conditions, no special advantage accrues to the owner in knowing in advance the cost of construction, and a cost-plus contract is eminently appropriate. On the other hand, the project may be under consideration by

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bankers who will not endorse it without having a definite bid from reputable contractors to construct the work at a fixed figure, such a decision eliminating the cost-plus form of contract as ordinarily written. In this connection, it may be noted that the head of a large banking firm in this city recently told the speaker that if his firm should ever undertake to finance a project to be done on the cost-plus basis, he would want to resign from the firm.

The experience of the speaker's firm with the cost-plus form of contract has been satisfactory so far as the character of the construction is concerned. As to the cost of the work, however, as compared with that of similar work done under a lump-sum contract, the speaker's information is insufficient to venture an opinion. He does know, however, that the cost of engineering will be greater for a cost-plus job than for a lump-sum contract, provided the engineer is required to approve the bills in addition to his other duties. This difference may easily amount to an appreciable percentage of the total cost of the work. In consequence, the cost-plus form of construction must show to the owner an appreciable saving over the cost of a lump-sum job in order that the ultimate cost of the two jobs to the owner may be the same; that is, unless the owner is willing to accept the work of the contractor without approval of his bills by the engineer.

There is one form of cost-plus contract which has not yet been mentioned, namely, that where an upset figure is given, which the contractor guarantees not to exceed. The speaker knows two or three construction jobs which have been carried through recently on this basis. Such a contract has the advantage of giving the owner a definite knowledge of the maximum cost of the construction, and is better in this respect than a lump-sum contract, owing to the probable addition of some charges for extra work in the latter case.

A point which has been brought up by one of the speakers is that it may be impossible for newly organized firms to get work on a cost-plus basis, inasmuch as the only competitive element in contracts let on such a basis is the reputation of the organization for efficient and satisfactory work. While ad-

mitting that it may be difficult for firms without a reputation to obtain such work, the speaker knows that it is not impossible, because of his association with a recently established organization which has taken a considerable amount of work on the cost-plus basis. In this case, the heads of the company were well-known, but the organization itself had no construction record.

R. A. HALE.* — I think there are a great many reasons for considering either of these contracts as being advantageous in certain cases. As Professor Allen says, in case of building a mill, where you go out into the field and everything is perfectly clear, there is no question but that the lump-sum method can be used with advantage. But where you have to do with raceways, cofferdams, etc., the element of uncertainty always comes in, in which case the cost-plus contract would seem to be better. This was the case in Lawrence, and all the large mills were built on the cost-plus basis. One of the large corporations which has been very successful has had all of its work done for years on a cost-plus method. It has a contractor who has been there for many years and who does things in a first-class manner, and no doubt, where uncertainties come in, has its work done cheaper than it would on any lump-sum method.

We also have an example in Lawrence of a mixed form of contract, combining both the lump-sum and cost-plus contract. This is the Central Bridge, which has just been completed. The first intention was to award the contract on the lump-sum basis, but owing to some error and legal complication the contractors were finally allowed to build it on the cost-plus basis up to the springing-line of the arches, and above that on a unit-price basis. That brought all the uncertainty on to the City, and the contractors certainly took advantage of it in every way. For example, the water in July, 1917, rose 10 ft. higher than it had for twenty years, and, of course, the expense all fell on the City. The work was not carried on to advantage. I do not think that the contractor was especially efficient, and this made the cost very excessive, so that, although the work was estimated to cost about $400 000, it has cost pretty nearly $1 000 000.

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I think, with perhaps a different contractor, one who was more familiar with that type of work, the cost might have been very much reduced.

E. F. LARNED.* — I think there are conditions prevailing to-day that must be recognized to be very greatly in favor of a cost-plus form of contract. It has become exceedingly difficult to get the usual number of proposals on a lump-sum basis, for work of a more or less hazardous nature, because of the uncertainties attending work these days. Labor is not a fixed commodity or quantity any longer. The contractor not only finds a shortage of labor, but he finds a constantly changing condition, which makes a careful, conservative estimate of cost impossible. Further, an element has been introduced into the cost of work that nobody can estimate, and that is the cost of delay. Delay to-day means something entirely different from what it did a few years ago. Previously, for instance, if the work couldn't be pursued on a certain day the men would be informed, "We are not going to work to-day. Come around to-morrow." But now the contractor cannot do that; if he did the men would not appear the next day, having gone to work somewhere else. The men must be kept on the pay-roll and assured of a pretty good sum at the end of the week, or they will go elsewhere. I think one step in advance might be taken on the lump-sum contract if that were not made so burdensome and sometimes so perfectly unfair to the contractor. The entire responsibility should not be put upon him. The engineer is forced, by the nature of the work, into the position of being not only the sole judge of the character of the work and of the methods of its conduct, but also arbiter in case any disputes arise. This is a most unfortunate position to force engineers into.

Another element is the more or less speculative nature of all contracts. Uncertainties always exist, and although the contractor takes them into account they sometimes prove to be very exceptional and involve a very high cost in their solution, and yet the contractor has no redress. It does not seem entirely right that the contractor should be made to carry all that burden. If he is efficient he can overcome the difficulty when it arises, but

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he cannot foresee the difficulty, and its cost should not fall upon him unless he has provided for it. If the form of contract were not so drastic, contractors would feel more disposed to make, perhaps, lower competitive bids, because they would then feel that in case of any unusual condition arising that called for arbitration, the matter would be settled on its merits, but now they feel that such matters demand litigation and they have found from bitter experience that litigation is expensive.

I think, therefore, that some form of arbitration clause should be introduced in all lump-sum contracts, and that while the engineer in charge of the work should be closely identified with the arbitration I think he should not be the arbiter. I think that this should be taken entirely out of his hands. The board of arbitration ought to be constituted of outside men, and while the engineer would be appealed to on any doubtful points, just as would the contractor, he should not be the sole judge, because it is difficult for the engineer to be totally unbiased by the connections that his position necessarily involves. He is employed by one party to the contract, and he primarily represents him, and it is the experience of almost everybody having to do with a great variety of work, that the contractor has a pretty slim chance, as a rule, unless he has a very, very clear case. He isn't given the benefit of the doubt. The case must be so apparent and clear that there can be no question about it.

Leonard Metcalf.* — I have been very much interested in the discussion to-night, because it seems to me it has given point to various things, especially to the change which conditions have undergone in the last decade or two, and which have had an influence on the method of letting contracts. We have to-day a very large number of contracting firms competent to handle large work admirably and with dispatch. This has broadened the point of view of the contractor; has changed the nature of his work; and has made it more of an administrative problem. To-day the work of the contractor is more of a profession than it was ten or twelve years ago; consequently we may look for better coöperation and better results than formerly.

I had the pleasure of serving with the committee in Wash-

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ington which prepared the emergency contract which has been referred to, so I know the governing motives behind it. The one idea that I should like to emphasize with respect to its application — one to which Professor Allen has referred — is that it was essentially an *emergency* contract. The more the committee considered this question, the more it realized the unparalleled magnitude of the construction problem and the tremendous hazard element involved in it with soaring labor and material prices. So the only criticism — if it can be called criticism — that I would make of Professor Allen's statement, is that in the work to be done under the emergency contract in building the cantonments, it was felt that the hazard element, alone, might increase normal cost not only 5 or 10 per cent. but by percentages which might run to 30 per cent. or more in some cases. The principle of relieving the contractor of uncertainty and hazard was the only one which could be utilized to keep the cost of the hazard element within bounds. Of course the lack of time presented the most serious difficulty. Common prudence dictated the employment only of thoroughly competent and experienced contractors to do the work. Those two conditions — the time element and the responsibility element — immediately eliminated the small contractors, because it would have been absolutely impossible to handle work on any such scale by a centralized form of control from Washington, which would have been involved by subletting or dividing up the work among small contractors. The biggest, most experienced contractors had to be selected.

I well remember that on some of the first recommendations to the Department, or to the Secretary of War, submitted for their approval or rejection, — approval, as it happened, — the statement was made that while other contractors had been suggested to us, they had never before done work of such magnitude, and that it was not thought wise to take any but men who had done work on a large scale, and that the commission on work that was done by subcontractors was a very much smaller element of cost than would have been involved by the hazard of pursuing the other course of action.

I feel very keenly the force of what Colonel Gow has said

with regard to the attitude of the Commission. I feel sure that all the men who sat down to select contractors for the cantonment construction felt that their reputations might suffer later on as a result of political pressure and influence. Every man had honesty of purpose and sincere desire to further the best interests of the Government. It appeared safer to limit the work to contractors of wide experience, from whom the quickest results could be hoped; and I think, in retrospect, the action taken was a wise one. Mistakes were made, of course, but as a whole, reviewing the outcome of the effort and comparing it with the expenditure of millions by some of our cities, the results attained confirm the judgment of the Committee.

There was discussed at that time the expedient of letting men bid on the percentage for which they would do the work, but this idea was rejected, as it introduced the hazard element again, — because the inexperienced man was the very man who would have been likely to give the lowest bid.

I accentuate these facts to bring home to you the abnormal conditions and the emergency character of the work with which the Government was confronted. Of course the hazard element in conditions, labor or materials, may exist in other works and does exist in many classes of work, and to those jobs this form of contract is particularly well adapted.

Personally, I do not believe it is well adapted to or workable under our American municipal and political conditions. On the other hand, for private work or work of large corporations, it has advantage in some cases. There is a very strong feeling, among manufacturers especially, that they prefer to know beforehand, just what the work is to cost rather than to take the hazard of the cost-plus basis, and that they prefer to pay what is necessary to get that comparative certainty beforehand.

I have already spoken of the necessity for decentralizing such large work as this, which in itself implies thoroughly competent men to take charge of the work on individual jobs. For example, the cantonment work could not have been done nearly so promptly if all of the work had been planned at Washington. The work had to be done on the ground. Of course, general sketches were made and the interrelation of the different

departments was determined from Washington. The work was controlled from Washington, but the work of designing and building was done essentially on the ground.

The most serious difficulty with this form of contract, as I viewed it, was a purely psychological one. Reference has been made to it, I think. It is the effect upon the workmen themselves. It does have an effect upon the workmen to know that the owner is doing the work on the cost-plus basis, and that the contractor's compensation is not dependent upon the skill and efficiency with which the work is done. Now, under conditions where there is great competition for the positions, this may not have so serious an effect as it has under those conditions where there is a shortage of labor, because that makes the point of view of the individual more independent.

The accounting may be done by two general methods. That was also a matter of a great deal of concern to the Committee at Washington. It was the belief of the Committee that the most effective way to do it was to have but one body of accountants, and that the large contracting firms already had the necessary organizations which could be used more advantageously than to build up a new corps, provided that the Government did enough accounting to thoroughly check the results. The books were to be open always to the Government. The other scheme — to have two full sets of accountants, the one the Government's, the other the contractor's — involved much more serious duplication of effort and cost. An effort was made to adopt the first. It was found impracticable. Of course the Comptroller of the Treasury wasn't ready to audit the accounts until his men had approved them on the ground. The Committee realized the danger of delay in the settlement of accounts, usual to Government contracts. So the Committee strove to have the Comptroller appoint representatives at the various important construction jobs to settle the bills monthly, finally, in a way that would enable him to satisfactorily account for the funds. But that proved impossible. The result was that a large new organization was built up, with methods not born of contractors' experience, but of accountants' experience, which were extremely burdensome. The difficulties were eventually righted through the

pressure of the situation. Delays to the work resulted, and when those delays were brought home to the accountants they realized that they must give way. They were then ready to make use of the experience of the contractors in developing methods which were adequate and which were easy of application, which led to more expeditious results.

I want, too, to bring home the difficulty of building up a large organization and of developing good team play. That, of course, is the one thing you must get, and you actually get it when you employ a competent concern.

I think the previous speakers have been quite right in their point of view that the contractor's reputation is his best asset, and that millions of dollars' worth of work are being assigned daily purely on personnel. It is also interesting to see how certain concerns or groups of men have come up, gone backward and come up again.

So much for the general statement of the cantonment work.

I promised Mr. E. S. Dorr, of the Sewer Department in Boston, to present for him a new form of contract, which is a modification of the cost-plus contract, which he prepared for city use and in which he has been very much interested. I am exceedingly sorry that he is not here himself to present it, but he is one of that splendid group of enthusiasts who have undertaken to maintain the arm of the law in Boston, and were not able to come to-night.

I also want to call your attention to another form of contract, published in *Contracting*, September 15, 1919, by Dr. J. A. L. Waddell, of Kansas City, in which he suggests the fixing of a certain price and the variation in the proportion of the return which shall go to the contractor or the individual, according as the final price is greater or less than that amount. It has merit, I think, in principle, but it seems to me it would be difficult of application for the very reason which Mr. Hodgdon has called your attention to, to-night. It gets back to cost accounting, which in many works is difficult.

I shall now read a letter which Mr. Dorr wrote to Mr. Thomas F. Bowes, to accompany his proposed contract:

Mr. Thos. F. Bowes,
Engineer in Charge:

Dear Sir, — I send you herewith a tentative draft of a competitive "cost-plus" contract; this is not a contract, but is a statement of the controlling features of one.

The Federal Government and private corporations during the war did vast amounts of work under cost-plus contracts. The reasons for adopting this form of contract were the great war exigency and the great uncertainty as to prices of materials and labor. With the exception of the war exigency these conditions continue and are likely to continue for an indefinite time in the future.

Under these conditions a contract, particularly for underground work, is a gambling rather than a business proposition, and is unfair both to the contractor and to the city (or state). It is unfair to the contractor because he may suffer on account of fluctuations in prices which no one can foresee.

It is unfair to the city because, to insure himself against such losses, the contractor must assume and bid the highest prices which may obtain during the life of his contract; the city therefore pays for risks which may not materialize.

Prices must decline at some time, but no one knows when. Under an item on lump-sum contract, if this decline occurs during the life of a contract, the city would not share in the saving; under a cost-plus contract, it would.

There are, therefore, valid reasons for the adoption of a form of cost-plus contract, provided one can be devised which is fair and cannot be abused.

For the use of a city or state, the contract must be competitive; this was not necessary for the Federal Government. It is also desirable to supply an incentive for economy (not apparent in the federal contracts), and for speed without sacrifice of economy, also not apparent in the federal contracts except through the natural desire of a contractor to finish quickly in order to get more contracts.

I have, therefore, formulated a contract containing these elements, viz., competition and incentive to economy and speed.

The reason for some provisions and percentage also requires brief explanation.

The difficulty in formulating a *competitive* cost-plus contract is in establishing a real and controlling relation between the bid and the payments for the work, which will also be fair to both parties. Competitive cost-plus contracts have been made in which the contractor was required to state his estimate of cost, and received in payment the actual cost of the work, plus a fee, and plus a bonus or minus a penalty, according to whether he had made the actual cost less or more than his estimate. This would work all right, provided the actual quantities correspond to the estimated quantities, but if they do not, the result is complicated. For instance, the actual cost might exceed the estimate due wholly to an excess of the actual over the estimated

quantities, when at the same time the actual item cost had been made, through efficiency in the management, less than the estimated item cost.

By the provision for an itemized bid, and the provision for a "modified estimate," a complete means of correction is supplied. The modified estimate is the estimate which the contractor would have made in his proposal, had it been possible for him to have known beforehand just what the actual quantities would be. Bonuses and penalties are then figured upon the basis of the modified estimate, and not the original estimate, which is just.

The reasons for making the fee a percentage of the estimate, for making it as high as 15 per cent. and for fixing the percentage instead of having it bid, are as follows:

If the fee were made a lump sum, this sum would have to bear a percentile relation to the estimated cost; it is simpler to make it a percentage.

The size of the fee compared to the estimate makes but little difference to the contractor in making his bid; he is then making up a sum, called the "arbitrary sum," which is to be used in comparison of bids, and will try to keep it low, so as to secure the contract. If he concludes to reduce this sum, he would naturally do it by cutting down on the fee; he would keep the estimate high and the fee low, because a high estimate increases the chance for a bonus, and because the fee is the fund from which penalties are taken, and as soon as it is exhausted, he escapes control in a large measure. As the contract is framed, his only way of reducing the arbitrary sum is by reducing the estimate (and time); which reduces the amount although not the percentage of the fee. If the fee is reduced unduly in this manner the contractor has no grounds for complaint.

It should be observed that the modification of the fee is to be for precisely the same reason and in the same proportion as that of the estimate; it is a purely corrective measure. It is based upon changes in quantities only, and is not affected by efficiency or the lack of it.

The provision for bonuses and penalties covers the features of efficiency. The bonus of 75 per cent. of the saving on the modified estimate may appear to be large, but is essentially just, for if a contractor can save anything on an estimate made in competition he is entitled to the largest share of it. But there is another practical reason for making the bonus large. The weakness of a percentile contract is in the opportunity it offers for fraud by padding pay-rolls and double billing of materials; a large bonus minimizes this evil; it would not pay a contractor to risk his reputation for what little there would be in it for him.

The aim of the writer has been to devise a form of percentile contract which would attract able and reputable contractors, and would induce and compel each one to bid just about what he thought he, with his resources, could do, and then make good on it and better it if he could.

This is, of course, the ideal which we should strive to attain in formulating a contract.

Experience may show that some percentages can be changed with ad-

vantage, but I believe the general form will stand the test of use, and while not wholly fraud-proof (which is impossible) will be found to be fairer, more businesslike and less susceptible to abuse than any other now in general use.

Copy of federal contract enclosed for comparison.

Respectfully,

E. S. Dorr,
Office Engineer.

Outline of Proposed Competitive "Cost-Plus" Contract.

Proposal.

(*a*) The City shall furnish a list of the items of the work, substantially as in the present form of contract, including estimates of quantities of all kinds of lumber which it is intended to incorporate in the work or leave in, and including an itemized statement of the quantities of materials which the City will furnish with values of such materials. The contractor shall bid prices on all other items.

It is to be understood that the quantities stated in the proposal are assumed solely for the purposes hereinafter described in paragraphs (*b*), (*d*), (*e*), (*f*), (*g*), (*i*) and (*j*). The commissioner does not expressly or by implication agree that the actual amount of work will even approximately correspond therewith, but reserves the right to increase or diminish the amount of any class or portion of the work as he may deem necessary.

If the price of any item bid by the contractor, or the sum total of all the items, is obviously abnormally high or low, the commissioner reserves the right to reject the proposal.

If required so to do, the contractor shall furnish evidence satisfactory to the commissioner that he has ability and experience in this kind of work, and that he has sufficient capital and plant to enable him to prosecute the same successfully, and complete it *within* the time hereinafter stated by him; and the commissioner reserves the right to reject any or all proposals or to accept any proposal, should he deem it for the interest of the City so to do.

(*b*) The City shall compute, as a lump sum, the contractor's estimate of the total cost of the work, exclusive of his fee. This lump sum shall be made up by adding together the values of the items of the work (including the materials to be furnished by the City), reckoned at the prices stated by the City for materials furnished by it, and at the prices bid by the contractor for materials and labor furnished by him, in the proposal.

(*c*) The contractor shall state, in number of working days, the time required by him for the completion of the work.

(*d*) The contractor shall receive, as a lump sum, a fee as full compensation for his personal services and that of his organization, including profit and all general overhead expenses, except as hereinafter otherwise provided.

The fee shall be 15 per cent. of the contractor's estimate (unmodified), including the value of the materials to be furnished by the City. This sum shall be used as the fee for comparison of bids only; it may be modified for payment as hereinafter described.

Comparison of Bids.

(*e*) Bids will be compared on the basis of an arbitrary sum to be computed by adding together the three following sums:

1. The lump sum reckoned as above stated as the contractor's estimate of the cost of the work;
2. A sum obtained by calculating 1 per cent. per month (thirty days), or 1/30 of 1 per cent. per day of the "estimate" for the "time" stated by the contractor as required by him for the completion of the work;
3. The lump sum to be received by the contractor as his fee.

(*f*) This arbitrary sum will be calculated in the manner described above, from the bid of each contractor for the purpose of comparison of bids only, and the smallest sum so obtained shall be considered the lowest bid.

Modification of the Estimate.

(*g*) If the quantity in any item of work shall be found to exceed by more than 10 per cent. the amount of such work estimated and stated (as above), the estimate shall be increased, for the purpose of calculating bonuses and penalties (to be hereinafter described), by the amount of the cost to the contractor of such excess, reckoned at the item prices as stated in the proposal.

And if the quantity in any item of the work shall be found to be less by more than 10 per cent. than the amount estimated and stated (as above) the estimate shall be decreased for the same purpose and in the same manner as above described for an increase.

If the commissioner of public works shall order the contractor to perform "extra work," the contractor shall do such work to the satisfaction of the commissioner and in such manner as he shall direct, and the estimate shall be increased by the cost of such work as determined by the commissioner from the force accounts.

Modification of the Time.

(*h*) If the estimate shall be increased or decreased for the reason stated, the time shall be correspondingly increased or decreased by the same percentage in days that the increase or decrease in money bears to the original estimate, and for the same purpose. The time may be increased (in addition) by the commissioner of public works of the City, on account of inclement weather, or by delays caused by the City, or otherwise, for which the contractor is in no wise responsible.

Modification of the Fee.

(*i*) If any increase or decrease shall be made in the quantities, a corresponding increase or decrease shall be made in the fee, that is, the fee shall be increased or decreased by the same percentage of the fee that the increase or decrease in the cost of such quantities, reckoned as stated in the proposal, bears to the original estimate. Moreover, if an increase shall be made in the estimate on account of "extra work," a corresponding percentile increase shall be made in the fee, as in the case of an increase in the quantities.

The fee shall be increased by bonuses and decreased by penalties on economy in the cost and in the time of completion of the work as hereinafter described.

Bonus and Penalty for Economy in Cost.

(*j*) If the total cost of the work (exclusive of the fee) shall fall below the contractor's estimate, modified as above described, (*g*), he shall receive a bonus of 75 per cent. of the difference; and if the cost shall exceed such estimate the contractor shall suffer a penalty of 50 per cent. of the difference, such bonus of penalty being added to or subtracted from the modified fee (*i*).

Bonus and Penalty for Economy in Time.

(*k*) If the total time occupied by the contractor in doing the work, modified as above described, shall fall below the time estimated by him in his proposal, he shall receive a bonus of 3 per cent. per month (thirty days), 1/10 of 1 per cent. per day, of the estimate modified as above described, for the difference in time between the time estimated and the time used; and if the time used shall exceed the time estimated, he shall suffer a corresponding penalty calculated in the same manner, such bonus or penalty being added to or subtracted from the modified fee (*i*).

Payments.

(*l*) Payments for labor and materials shall be made monthly, for labor as shown by the pay rolls checked by the force accounts, and for materials as shown by receipted vouchers.

There shall be no partial payments on account of the contractor's fee.

The fee, modified as above described, shall be paid to the contractor upon the completion and acceptance of the work.

Approval of Cost of Materials.

(*m*) The contractor, before purchasing any material, shall submit to the commissioner a statement of the quantity and price of the material he intends to buy, and shall purchase only upon the commissioner's approval of quantity and price.

(*n*) The City may furnish, at any time, any materials other than those stated in the proposal; the cost of materials purchased by the City for said work, exclusive of all freight charges thereon, shall be included in the cost of the work for the purpose of reckoning the fee to the contractor and the modified estimate, but for no other purpose.

VICTOR H. CLARKE.* — I have been much interested in the discussions this evening. It has been one of my duties, since joining the forces of Stone & Webster, to read most of the articles which have come out regarding cost plus. Although I am opposed in every way to the lump-sum contract, or guaranteed-cost contract, — which I believe are identical in so far as the incentive is concerned, — following along the suggestion made as to the psychological effect on the workmen of any kind of cost-plus contract, I should like to tell of an article (I don't know how many of the members may have read the article) printed recently in one of the engineering papers, regarding a Canadian firm of engineers which awards work on the above-stated (guaranteed-cost) basis. They take the estimate of the successful contractor and award the work on, we will say, a 20 per cent. commission basis, with the provision that for every dollar expended on the job he must pay to the owners an amount equal to 10 per cent. of same. In other words, if the job costs what he estimates, he will receive 10 per cent. net on the job. But the idea is that the workmen on the job are told that for every dollar spent it is costing the contractor 10 per cent. Satisfactory results have been attained, and the contractor has been able to get the work out of the workmen. That is a psychological way of getting around this difficulty.

I was interested in the remarks about cost of the plant. We have had very little trouble in settling at the end of the job, on account of the plant cost. Of course, we usually recommend buying new equipment on a job, the work generally being of such size that it pays to buy new equipment, and the upkeep on such equipment is very small. If, however, second-hand equipment is asked for, this equipment is appraised by disinterested parties, and that is the price at which the job is charged, and when the job is over it is either sold to outside parties or we take it upon an appraised value, so that the job is charged with depreciation only. If the owners wish, we will rent equipment, but we have found almost invariably it is cheaper to buy and sell than it is to rent. We find second-hand equipment seldom pays on large jobs. We have had very little trouble, and the owners are entirely satisfied in this plant cost.

* With Stone & Webster, 147 Milk Street, Boston.

The vice-president of the Westinghouse-Church-Kerr Company in an interview stated that when they first started out they undertook lump-sum work, and later on they took work on a percentage basis, or for a fixed fee, and frequently they would have several jobs going at the same time, some on lump sum, others on percentage, and still others on a fixed fee, but he used this very apt expression, — "We have abandoned competitive bidding and have agreed to work only for the client," — meaning that when they were on a lump-sum or guaranteed-cost basis they were working for themselves.

As I remarked when I first started, I am very much opposed to lump sum or guaranteed cost, for under those forms the contractor is working for himself. He is not able to give to the owner the entire benefit of his years of experience, because he is giving that to himself, whereas on the cost-plus basis he is able to give to the owner every bit of knowledge and experience he has gained through these years of contracting, and the minute he is limited to an upset price he is going to begin to work for himself. In other words, the contractor who is doing work on a lump-sum basis usually cares only to finish that job and bid again, whereas the man on a fixed-fee basis carries on his work so as to build again.

We are endeavoring to talk to our prospective clients not so much as contractors as we are as professional men. We are selling a service. We are not merchants, buying building materials and then selling a building. We are selling building service. If I may be permitted, I should like to bring out a little of our personal experience. The question has come up about making estimates for bankers. I was analyzing, the other day, some of the work we have done in the last few years, and I divided the work up into several groups, — hydroelectric work, steam-power work, government work and industries; and I found in the last four or five years we have done 26 jobs for industries — building work, we'll call it — for a total of about $30 000 000, and on three jobs our completed cost exceeded our estimated cost at an average overrun of 2.6 per cent., and we finished 23 jobs under our estimate at an average underrun of 3.6 per cent., which ordinarily would be accurate enough to permit anybody

to finance their enterprise. With the average lump-sum bid that a banker would take in building an office building, the extras would amount to considerably more than that.

H. E. Wheeler.* — There is one feature of contract work which has not been dwelt on very thoroughly. It does not occur so much with engineer's specifications as it does with a certain class of architects who do not use a uniform contract. They will submit a set of specifications to a contractor so drastic in its provisions as not to leave the contractor even a mind of his own. I have seen a great many of these specifications which are conflicting and take away all the liberty of the contractor. They contain blanket clauses which will force the contractor into litigation to break them, or break the contractor. They will specify flatly what type of work is to be done and then cover themselves by blanket clauses which state that the work must conform to all local ordinances and also to the full intent and meaning of the specifications and plans, whether that meaning is clear or not. In some cases it would necessitate the contractor being a mind reader to know what the intent was. It also makes it necessary for the contractor to know absolutely all local ordinances governing in the region where the work is to be built. It seems to me that it should be the duty of the architect to know the regulations and embody them in his plans and specifications. I have known this to result seriously in a number of cases where the contractor had taken it for granted that the ordinances would not vary greatly from those where he was accustomed to doing business and afterwards found the law in that locality very drastic.

We had a case recently where the owner came to us with a set of plans and asked for an approximate estimate, giving the impression that he did not want a close figure, but some idea as to what the building would cost, indicating that he would be willing to do the work on a cost-plus basis. We gave him an estimate and after receiving it he wanted us to sign a contract for that amount. We refused more as a matter of principle than anything else, and told him that if he wanted us to sign for the work on a contract basis, we would have to increase our approxi-

* With L. H. Shattuck, Inc., Manchester, N. H.

mate price 5 per cent. We lost the contract, which we understood was let 3 per cent. lower than the approximate figure we gave. One trouble with contract work in the past, I have noticed, is the narrow-minded attitude of architects and engineers. The remedy for this trouble would lie in the fundamental education of the architects. I know several prominent architects and engineers who claim that until the contract is let they are agents of the owners, but after the contract is let they are agents of the contractors as well as of the owners, and feel it their duty to protect the contractor from an unreasonable demand, as well as their duty to protect the owners from faulty workmanship. If architects and engineers could more generally take this attitude, there would be less trouble in contract work, but the attitude of architects, generally, is that the contractor is guilty until he proves himself innocent, and then the architect refuses to give him a chance to prove his innocence.

I have knowledge of a contract which has been used satisfactorily at several times, which is much on the same line as Mr. Dorr's, but not so complicated. It has to do with estimated cost with fixed percentage or fixed fee, and variable forfeiture for exceeding the estimated cost, of a percentage of the contractor's fee, and a bonus in percentage of the amount saved. For instance, a contractor takes a job for $100 000 plus 10 per cent. If he exceeds it by $5 000 his fee is to be reduced by a percentage of the excess. If he saves he gets a percentage of the amount saved. I know of that contract having worked very favorably a number of times. It has the feature of competitive bidding and awarding of contract on that basis, and then it gives the contractor an object to keep his cost down to increase the amount of his fee.

The psychological aspect of labor has been spoken of a number of times. Personally, my experience of labor in the last few years has been that the psychological aspect can be discounted, because under union conditions the question of psychology is lost sight of by the laboring man himself. As they have become strongly unionized and the cost of labor has gone up, their efficiency has decreased in inverse ratio.

P. A. SHAW.* — Until I went with the Shattuck Company I had always been an engineer in private work, and had done a great deal of municipal work also, and I think I can look at a contract from both sides. I think, as far as municipal work is concerned, the cost-plus contract must await the millennium. I think we must leave it to the cities to be satisfied with taking the lowest competitive bidder. On account of legal restrictions, we must leave the cities to be practiced on by the inefficient contractor until he is good enough to work for individuals.

We are working on the cost-plus basis to a considerable extent. It is purely and simply a basis of confidence. For instance, take one of the largest contracts which we have on the cost-plus basis. When we got the job we had an architect's picture and made an estimate of what it would probably cost, and before the architect had any dimensions we had the cellar foundations started. On another, we had simply one line around a blue print, and were told the general nature of the building. In that case we bid percentages, — that is, the contract was awarded on the basis of the estimated cost of the building and the least percentage of profit. It was a private job, however. If it had been a public job some ignorant person would probably have bid a ridiculous price and received the work.

The thing seems to me to boil right down to a proposition of professional service. We are working directly for the client on cost-plus work, and we have only one thing to lose, — and that is the most valuable thing we have, — our reputation. The contractor has his reputation to lose, and if he loses that he knows he will get no more cost-plus work.

As for the contractor's slighting cost-plus work and giving his best attention to the lump-sum, — we were working on both kinds of contract in the same city, the other day, and could get only one concrete mixer in time for some concreting on both jobs. Our superintendent said that the mixer must go to the cost-plus job, and that we must mix the other job by hand. So, if you are working to build up a reputation and keep a steady clientele, it isn't a question of slighting the cost-plus work, it is a question of slighting the contract work, which you have a

* With L. H. Shattuck, Inc., Manchester, N. H.

perfect right to do, as work done at a disadvantage comes out of your pocket.

In regard to plant rentals: we were asked to bid on a lump-sum fee that was to include the rentals. That was one party's way of getting around the rental proposition. He had previously let a contract to a contractor who had a miserable plant which had to be rebuilt at the cost of the job. We have only one large contract on the lump-sum basis, and in that case we have the arbitration clause. It states there shall be an arbitration board for any matter which comes into serious dispute. As for a contractor's starting in on the cost-plus work, it doesn't seem possible until he has made his reputation. He can bid on contract work and practice on municipalities until he has a reputation, and then go ahead on cost-plus work for individuals, which is much more satisfactory work.

James W. Rollins * (*by letter*). At the request of the Secretary, who furnished me with a copy of the discussions, I am writing out my views on the subject of contracts.

To state my "platform," I do not believe in any cost-plus or percentage contract, unless there is great uncertainty as to the work to be done, or the cost of labor or material.

Great prominence has been given to percentage contracts because under war conditions, and especially as to work done for the Government, they were the only practicable form to be used, where work has to be done regardless of cost. The Government work was honestly and reasonably done, though no real contractor would "stand for" the inefficiency of labor that had to be used on these jobs. When carpenters, so-called, may be "botch carpenters," barbers or grocery clerks, and come to the contractor as union men, the Government accepts them, but no contractor would. "Put on men" is the slogan, and men go on, whether or not they know what an auger is other than to describe it as a tool that you "turn round and round," or to whom a cross-cut saw is the same as a rip saw. It looks well to show one thousand men on reports as working, though five hundred good men would do more work.

Our corporation up to war times did practically no per-

* Of Holbrook, Cabot & Rollins, 6 Beacon Street, Boston, Mass.

centage or cost-plus work, and never sought for any. We were ready to gamble with our own money and brains, and take straight contracts; and in twenty years of work, which covered some of the most difficult work done in New England, — mainly water work, — our losses were very small, and our profits satisfactory. In my judgment, percentage work of any kind tends to laxity on the part of both the engineers and contractors.

In straight contracts, the engineer must make his plans and specifications with great care, so that the contractor knows just what he has to bid on, whereas if the work is done on a percentage basis, he can start with indefinite plans and change anything at any time and at any place. And the contractor cannot feel the responsibility or interest in the work when he feels that plans may be changed or that the engineer or owner is liable to come around and tell him how to do the work; when the contractor, knowing that the engineer or owner thinks differently, but must pay the bill, changes his plans and does the work, probably at greater expense, in the way his clients want. In one large job we did on a percentage basis, the engineer took entire charge and neither our superintendent nor myself were asked or consulted about the ways or means; so our fee was paid for us for tool and plant only, and our experience went for naught.

Another fact that I have repeatedly noticed, is that when work has been done on a percentage basis, the engineers and inspectors have allowed material to be used, and work done, which they would immediately have condemned if the contractor had been responsible for it. There is a reason for this. In percentage work, theoretically, the engineer and his inspectors want the work expedited, and so if a pile is 12 in. instead of 14, or a foundation is an inch or two out of line, they let it go, rather than delay the work; whereas were it done by contract they would insist on exact compliance with specifications and plans, and let the contractor pocket the loss, and make up for lost time.

I cannot see any more satisfactory way for an owner to have his work done than under a suitable contract with complete plans, with the contract in the hands of the lowest responsible bidder. There is no excuse to offer if work, either public or private, is awarded to an irresponsible bidder or to one without

proper experience; and it is no justification to an engineer to do work on a percentage basis from fear that a poor contractor will get the job, when he has or should have the power to throw all such men out.

Percentage work can never be used for public work except in extreme cases, and, in my judgment, only in cases where work is indefinite or where the owner doesn't care for cost, or where the engineer thinks it easier to make his plans after the work is done.

A contractor is successful only as he makes money, and to do this he must use all his brains and resources to meet the demands of his work. He is alert to study all conditions, acquaint himself with what other men are doing, of the best plant and appliances available. The better he does all this the more money he legitimately makes by reducing the cost of the work. There is not this incentive when work is done on a percentage basis, for on that class of work cost does not come in, and but few engineers and almost no owners know whether the cost of the percentage work is low or high, and all they do know is that the work goes along well and the contractors are honest men and good fellows.

As an illustration of Government war contracts: The Navy Department asked for bids on piers in Boston, and got one bid of $500 000. This bid was thrown out and new ones asked for. I told one of the Government representatives that we would do the work on the same basis as we were doing the Army Base work, and my judgment was that the work would cost $300 000. The Navy Department would not do percentage work, so we made a bid of $440 000 and were the lowest of three bidders. We didn't get the job, because the money appropriated was not enough.

Any man who does only what he plans to do, is a failure. He must do better than he planned. So with contracting, it's a glorious game for a true sport; to be given a contract of great difficulty; to plan how he will do the work at a given price; then, as he does the work, to find some better and cheaper way; to beat Nature and the elements at their own game, and finish the work with a greater profit than he figured. Is it not reasonable to think a contractor plays the game better, on the above basis, than one who takes a contract with a fixed low percentage? He has no boss to tell him what to do, or to find fault with him

if something goes wrong; and if he wins out the glory and money are his. To me that's the game — real contracting; any man with a reasonable amount of brains can do most anything *in time*, if some one else will pay the bill; but there is no sport in that kind of work!

If some of the contractors who do practically only percentage work would give us their experience in bidding on work on regular contracts, we would get a better idea of the relative value of percentage and straight contract work. I have never heard of their being successful bidders on any public work, and do know of their reputation of being high bidders on private work. Engineers compare cost of work estimated at the cubic foot contents of a building. Unless buildings are of the same general plan, equally accessible to transportation, to material supplies at equal prices, to equal labor conditions, comparisons are invalid, and yet the percentage men gage the efficiency by these comparisons, and they satisfy their principals by them.

Regarding contracts: Most of them have some blanket clauses which are objectionable, but in our experience we have never been held up by them, and the courts are now looking with disfavor on them. They should be eliminated, and also those other clauses which make the engineer final arbiter. As a matter of fact, I do not think his position is ever maintained unless the questions go to court, and even then testimony is generally able to qualify his decisions.

I have had two kinds of experiences on percentage work. One where the engineers want to run the job; in which cases I have had no interest, and about as much satisfaction as buying and selling shoestrings. In other cases we have been given work, without cost and without price — simply told to do it at our own price and according to our own plans; and on these contracts I have worried more than on fixed-price work, and do not care for the responsibility of inspector and engineer, of explaining some item of cost, of why something went wrong, with the plant or men or natural conditions. For these reasons I do not care for percentage work, and have no great interest in it.

I think I should apologize for this long discussion, as I have written after reading the oral discussions of the meeting, and in that way have had an advantage.

MEMOIRS OF DECEASED MEMBERS.

CHARLES E. PUTNAM.*

Charles E. Putnam, a member of our Society since 1885, died at his home in Boston on August 20, 1919. He was born in Jackson, Waldo County, Me., August 10, 1859, the son of Daniel and Sarah A. (Tasker) Putnam, and the grandson of Daniel Putnam, an early settler of Searsport, Me., and probably a descendant of John Putnam who came to Danvers, Mass., from England about 1641. His mother was born in Dixmont, Penobscot County, Me., the family having settled there in 1812, coming from Ossipee, N. H., to which town earlier generations of the Tasker family had come from Dover, N. H., where the first of the name in New England, John Tasker, had settled after his arrival from England in 1680.

Mr. Putnam had been in poor health for some time when, on the day of the parade in April, of the returning 26th Division, A. E. F., from France, one of the soldiers being his only son, he watched the march from the reviewing stand on the Common, and caught a violent cold, which so aggravated his old trouble that he was obliged to enter a hospital where he underwent a surgical operation. The disease had progressed so far that it was seen that recovery was impossible, and he returned to his home where after several weeks of intense suffering he died.

Mr. Putnam graduated in 1883 from Maine State College at Orono, and very soon afterwards came to Boston and was employed on the Boston Improved Sewerage work, where he soon gave promise of a successful career as an engineer. In 1887 a large appropriation was made by the City of Boston for park construction, and it became necessary to organize an engineering force for that work. Mr. Putnam was appointed an assistant engineer at Franklin Park, under the direction of the City

* Memoir prepared by Edward W. Howe and Charles E. Houghton.

Engineer's Department. He also had charge of the engineering work at Jamaica Park, Arnold Arboretum, Franklin Field and some of the smaller parks and playgrounds.

In 1896, upon the separation of the supervision of the park work from the City Engineer's Department, Mr. Putnam for several months was acting superintendent of parks until the appointment of a permanent superintendent, when he was made chief engineer of the Park Department and continued in that office until his death.

Mr. Putnam showed great ability as an engineer, and, working in association with the landscape architects, was able to be of great assistance in the prosecution of the construction of our fine system of public parks. He also developed considerable architectural skill, and designed and supervised the construction of several park buildings. The public playgrounds also called for a good deal of skill and much detail work. All of this was done with such fidelity, honesty and a devoted interest in the work that no question was ever raised as to the character of his service, and the City of Boston owes him a debt of gratitude which, perhaps on account of his extreme modesty, was not always recognized.

Early in his career Mr. Putnam began to be afflicted with deafness, which was a severe handicap and made him of a retiring disposition, so that he was perhaps not very well known among our members; but for this he undoubtedly would have had a greater reputation, and we feel certain that he would have become a leading engineer.

Mr. Putnam married, in 1893, Miss Delia T. Drury, and after her death in 1911 he married her sister, Miss Elisabeth R. Drury, who survives him, as does also one son, Harold, who served in France with the 101st Engineers Regiment and is now in the employ of Messrs. Stone & Webster.

Mr. Putnam, in addition to being a member of our Society, was a member of the American Road Builders Association, the American Association of Park Superintendents, the American Society of Municipal Improvements, the Massachusetts Highway Association, Boston City Club, Dorchester Club and Boston Bowling Green Club.

LESLIE PETER REED.*

Leslie Peter Reed, son of Peter J. Reed and Mary Elizabeth (McDonald) Reed, was born in Hyde Park, Mass., on September 21, 1890. His family moved to Pepperell, Mass., when he was about four years old, and he lived in that town until he graduated from the Pepperell High School in 1908. From 1908 to 1916 he was an assistant to William S. Johnson, C.E., both in office and outside work. During this period he was a student at the Lowell Institute School for Industrial Foremen from 1910 to 1911, and at the Franklin Union in 1913.

While employed by Mr. Johnson he served as rodman, instrumentman, inspector on construction and resident engineer on various projects, among which were the Pepperell Water Works, sewage disposal works for the American Woolen Co. at Maynard; purification works for the manufacturing wastes from Tileston & Hollingsworth's paper mills at Mattapan; and water works at Ashland, Deerfield and Marblehead. Late in 1916 he was assistant superintendent with the Bay State Dredging and Contracting Company, Boston, on Wellesley Extension, Metropolitan High Level Sewer, Needham, Mass.

He went to work for the J. W. Bishop Company in the early part of 1917, as an assistant engineer, and was engaged at the Bridgewater Normal School and at the Naval Air Service Station, Squantum. When work started on Camp Devens he was loaned by the J. W. Bishop Company for work on the water supply and sewerage of that cantonment, and while there was admitted to the first Plattsburg Camp. In reply to a request to the J. W. Bishop Company for data relating to Mr. Reed, Mr. H. S. French of that company wrote in part as follows:

"He was admitted to the First Plattsburg Camp and assigned his commission after the completion of the course. I understood that he was offered a first lieutenancy with an assignment to one of the camps for the purpose of training men, or a second lieutenancy in the Signal Corps with a chance to go abroad immediately, and he took the latter. After a wait of several weeks at Camp Mills, he was transferred to duty in Washington and placed in charge of sewer work at various Signal Corps stations, receiving during this period his promotion to

* Memoir prepared by F. S. Bailey.

first lieutenancy in the Signal Corps. He was one of the first victims of the influenza epidemic. I have understood from officers who were closely associated with him during his period of service that he was unusually successful in the line of work to which he was assigned."

He was elected a junior member of this Society in 1913, and became a member in 1917. On May 13, 1917, he was married to Miss Dora Lunt, of Portland, Me.

Mr. Reed's military record, kindly furnished by the director of air service, is as follows:

"Entered the military service at Reserve Officers' Training Camp, Plattsburg, N. Y., August, 1917. Commissioned second lieutenant, Signal Officers' Reserve Corps, November 27, 1917, and was assigned to the Construction Division, Office of the Chief Signal Officer, which later became the Supply Division of the Division of Military Aëronautics, and is now known as the Supply Section, Office of the Director of Air Service. While on duty in this office he was in charge of design and maintenance of water and sewage systems at aviation fields and supply depots. He was promoted to a first lieutenant, Aviation Section, Signal Officers' Reserve Corps, April 8, 1918, with rank from March 25, 1918, and accepted this commission April 17, 1918. He served in this office from December, 1917, until September, 1918, when he was stricken with pneumonia. He died at the Walter Reed General Hospital, Washington, D. C., September 26, 1918."

As indicating the respect in which Lieutenant Reed was held by his associates in the army, the following letter from Major Burns to Mrs. Reed will be of interest:

SEPTEMBER 27, 1918.

My dear Mrs. Reed, — It was with the deepest regret that I learned of your husband's death, this morning. I have been actively associated with him here in Washington for several months past, and have grown to admire him exceedingly for the earnestness of his efforts, his clear, straight thinking and his forcefulness. These and many other splendid qualities have made him universally respected among those with whom he came in contact. His loss is a great personal blow to us all, and his keen ability and devotion to the cause he was serving so capably will be missed exceedingly.

Let me express my sincere sympathy, in which my associates join.

Faithfully yours,

EDWARD BURNS.

The following words from his obituary notice in the Pepperell *News* also show how he was regarded in his home town:

"Leslie Reed was brought up by his widowed mother, and forced his way to the front by sheer grit and natural ability. He was a loving and obedient son, a good pupil, a loyal husband, a true brother, and an honored citizen. He was a member of St. Paul Lodge of Masons, Ayer. He is survived by his wife, his mother, and brother, Walter Reed. He was born, married and buried on Sunday."

A letter to Secretary Tinkham from Lieutenant Reed's brother concludes as follows:

"Leslie always had a warm spot in his heart for the Society, as he spoke about it dozens of times to me.

"His wife, his mother and myself send our appreciation for all past and future interest taken by the Society in our best friend, Leslie."

It is safe to say that all members of this Society who knew Lieutenant Reed at all intimately felt the same regard and affection for him, and sense of loss at his death, as is expressed in the newspaper articles and letters just quoted.

Lacking a college education, he endeavored, with much success, to make up for the deficiency by studying at technical schools and at home after he was employed, and, as he grew in knowledge and experience, he seemed destined to become an even greater credit to the Society than he had, in his regrettably short life, already proved himself to be.

The writer was associated with him for several years, and found him to be a man endowed with sound common-sense; reliable in his work, not only when things were going smoothly but also when conditions were discouraging; good-humored, even-tempered, intelligent and tactful; of exemplary habits, sturdy honesty and thoroughly admirable character.

Vol. VII FEBRUARY, 1920 No. 2

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PROCEEDINGS

PAPERS IN THIS NUMBER.

"Maximum Rates of Precipitation at Boston for Various Frequencies of Occurrence." Harrison P. Eddy.

Memoirs of Deceased Members.

Reprints from this publication, which is copyrighted, may be made provided full credit is given to the author and the Society.

Contributors are hereby notified that proof will not be submitted to them for examination unless requested before the 10th of the month preceding the month of publication.

MINUTES OF MEETING.

BOSTON, January 28, 1920. — A regular meeting of the Boston Society of Civil Engineers was held this evening at Chipman Hall, Tremont Temple, and was called to order at 7.50 o'clock by the Senior Vice-President, Leonard C. Wason.

There were 139 members and visitors present.

The reading of the record of the last meeting was dispensed with and it was approved as printed in the January JOURNAL.

The Secretary reported for the Board of Government the election of the following candidates to membership in the grades named:

Members: George Budd, Jr., George C. Danforth, Howard W. Green, Henry C. Sheils, Miner R. Stackpole.

Junior: William W. Hall, Jr.

The Secretary submitted the following reports of committees appointed to prepare memoirs of deceased members, and by vote the memoirs were ordered printed in the JOURNAL of the Society: Memoir of Edmund Grover, prepared by Messrs. R. A. Hale and A. L. Plimpton; and memoir of Irving S. Wood, prepared by Messrs. W. W. Bullock and J. A. McKenna.

Mr. F. O. Whitney, for the Board of Government, offered the following vote:

"*Voted:* That in view of a probable deficit in the current expenses, a sum not exceeding fifteen hundred (1 500) dollars be appropriated from the income of the Permanent Fund to make good such deficiency."

Past-President Charles R. Gow offered the following amendment:

"That the entire income of the Permanent Fund for the current year be appropriated and placed at the disposal of the Board of Government for use in payment of the expenses of the Sociey so far as in their judgment it is deemed advisable."

Mr. Whitney accepted the amendment and in its amended form the vote was adopted unanimously.

This vote, in accordance with the By-Laws, will come before the Society a second time at the next regular meeting of the Society.

The chairman then introduced the speaker of the evening, Mr. A. N. Johnson, consulting highway engineer, Portland Cement Association of Chicago, who read a paper entitled "Construction of Concrete Roads." The paper was illustrated with lantern slides.

A discussion followed the reading of the paper, in which Messrs. A. W. Dean, E. S. Larned, L. E. Moore, F. B. Walker, and others took part.

On motion of Past-President Gow, the thanks of the Society were extended to Mr. Johnson by a unanimous rising vote.

Adjourned.

S. E. TINKHAM, *Secretary.*

APPLICATIONS FOR MEMBERSHIP.

[February 15, 1920.]

THE By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

MORTENSON, ERNEST DAWSON, Bedford, Mass. (Age 24, b. East Boston, Mass.) Graduate of Concord (Mass.) High School in 1913, and of Tufts College in 1917, with degree of B.S. in civil engineering. From June to September, 1916, chainman, and from May to September, 1917, head of party in Terminal Division, Engineer's Office, B. & M. R. R.; from September, 1917, to June, 1919, structural draftsman, B. & M. R. R., engaged in general drafting, computation and design of highway bridges and computing stresses of railroad bridges; and from July, 1919, to date, structural draftsman with Aberthaw Construction Co., at present designer of reinforced concrete buildings. Refers to S. P. Coffin, H. A. Gray, Pusey Jones, A. W. Knowlton, J. B. Mailey, E. H. Rockwell, J. J. Rourke and F. B. Sanborn.

ROY, JOSEPH ERNEST, Springfield, Mass. (Age 26, b. Springfield, Mass.) Graduate Worcester Polytechnic Institute, B.S. degree in civil engineering, 1915. From 1915 to 1918, with J. R. Roy & Sons Co., building contractors, as superintendent of construction, 1918; attended Mass. Inst. of Technology, completing intensive course in naval architecture, and 1918 and 1919, lieutenant (j. g.) Construction Corps, U. S. Navy. Elected a junior March 5, 1915, and now desires to be transferred to grade of member. Refers to C. M. Allen, A. W. French, H. C. Ives, A. J. Knight and A. W. Knowlton.

TURNER, HOWARD MOORE, Cambridge, Mass. (Age 35, b. Wareham, Mass.) Graduate of Harvard University, A.B. 1906 and S.B. in civil engi-

neering 1907. Rodman on construction at Harvard Stadium, summer of 1903; from June, 1907, to January, 1910, with Turner Construction Co., New York City, as instrumentman, in estimating department, and assistant superintendent on construction work; from January, 1910, to April, 1911, supervising engineer, Easthampton Gas Co., in charge of construction of 1 500-kw. steam station and nine miles of high-tension electrical transmission line; from April, 1911, to April, 1912, investigation and report work for Turners Falls Power and Electric Co., for their hydro-electric plant at Turners Falls; from April, 1912, to June, 1917, resident and later hydraulic engineer in charge of construction and detail plans for 60 000 h.p. development at Turners Falls; from June, 1917, to August, 1918, assistant to the president of the Turners Falls Power and Electric Co., Boston, in connection with future development at Turners Falls, steam station at Chicopee, high-tension line from Providence to Fall River and miscellaneous engineering work. August, 1918, commissioned first lieutenant engineer in U. S. Army; after two months in the E. O. T. C. at Camp Humphreys, assigned to 606th Engineers at that camp. From January 1, 1919, to date, in private practice with office in Boston. Lectures on Water Power Engineering at Harvard Engineering School. Refers to R. E. Barrett, H. J. Hughes, L. J. Johnson, H. A. Moody, J. R. Nichols and A. T. Safford.

LIST OF MEMBERS.

ADDITIONS.

DANFORTH, GEORGE C. 27 Weston St., Augusta, Me.
HALL, WILLIAM W., Jr. 99 Salisbury St., Worcester, Mass.
STACKPOLE, MINER R. 104 Queensberry St., Boston, Mass.

CHANGES OF ADDRESS.

ARONSON, MARK 65 Bainbridge St., Roxbury, Mass.
BARRETT, R. E. Holyoke Water Power Co., Holyoke, Mass.
BIGELOW, L. W. 1022 Main St., Worcester, Mass.
BOAS, BENJAMIN 224 Main St., Norwalk, Conn.
FALKENBERG, JOHN J. 3 Dartmouth Ave., East Dedham, Mass.
HARTWELL, HERBERT C. 108 Massachusetts Ave., Boston 17, Mass.
LAKE, HARRY E. 40 Temple St., Reading, Mass.
LONG, WILLIAM J.
Apt. 22, New Berne, 12th and Mass. Ave., Washington, D. C.
MCCORKINDALE, R. I. 130 Oakland Ave., Methuen, Mass.
MORRISON, HARRY J. P. O. Box 503, Gainesville, Fla.
NOLAN, CONRAD 303 Main St., Clark Bldg., Jacksonville, Fla.
PLIMPTON, A. L. 108 Massachusetts Ave., Boston 17, Mass.
ROURKE, LOUIS K. 6 Wayne St., Roxbury, Mass.
STEWARD, HARRY M. 108 Massachusetts Ave., Boston 17, Mass.

Sumner, Merton R.	Care Fuller Industrial Engineering Corporation, Room 1710, Fuller Bldg., New York, N. Y.
Sylvia, Manuel H.	29 Broadway, New York, N. Y.
Tozzer, Arthur C.	178 Tremont St., Boston, Mass.

DEATHS.

Fuller, Frank L.	January 30, 1920.
Pratt, R. Winthrop	February 2, 1920.

LIBRARY NOTES.

Book Review.

"The Turnpikes of New England: Evolution of the same through England, Virginia and Maryland," by Frederick J. Wood., member American Society Civil Engineers, member Boston Society of Civil Engineers, member New England Historic-Genealogical Society, lately major of Engineers, U. S. Army. Illustrated. Marshall Jones Company, Boston. Cloth, $7\frac{1}{2}$ x 11 ins.; pp. XVII + 461. $10.00.

Reviewed by Frank O. Whitney.

Major Frederic J. Wood, the author of the work with this title, gives to the public, as the result of ten years' study, a volume which is exhaustive, authoritative and human, and should appeal to the engineer, the historian and the general reader.

The turnpike as an institution was an important factor in the country's development during the first half of the nineteenth century.

At the close of the Revolutionary War, communication between the states forming the permanent union was primitive and difficult. As agents in laying the foundation for the amalgamation of diverse interests into a concrete body politic, the turnpike and the stage coach played a very important part, and can be compared with the importance economically of the great railroad extensions after the Civil War.

The incorporation of turnpike companies in New England

began in 1792 and continued for a century. In Massachusetts alone one hundred and eighteen charters were granted, but only sixty resulted in road building. The total investment in turnpikes in Massachusetts was about $2 380 000.

It is of special interest that the railroads have closely followed the lines of the turnpikes.

While the usefulness of the turnpikes is without question, financially they were losing ventures, there having been then as now a popular prejudice against public-service corporations.

Major Wood gives an historical sketch of each road, facts in connection with the construction and operation, together with over three hundred illustrations from photographs taken by himself. Several maps show the connection of the various roads into a comprehensive system reaching out into every important section of New England.

This is believed to be the first comprehensive history of American turnpikes, and, considering the difficulties of getting at the facts, it may be fairly classed among the remarkable books of the past twenty-five years.

Major Wood is a member of the Boston Society of Civil Engineers and the American Society of Civil Engineers. He was a major of engineering during the late World War.

Recent Additions to the Library.

U. S. Government Reports.

Boundary between United States and Canada. Joint report of Commissioners, 1918.

Chief of Engineers, U.S.A. Annual report for 1919. 3 parts.

Financial Statistics of Cities having a Population of over 30 000, 1918.

Interstate Commerce Commission. Thirty-third annual report. 1919.

Superintendent Coast and Geodetic Survey. Annual report for 1919.

U. S. Housing Corporation, Report of. Vol. 2. Houses, Site Planning and Utilities. 1919.

State Reports.

Massachusetts. Annual report of Homestead Commission for 1918.

New Jersey. Annual report of Department of Conservation and Development for 1918.

City and Town Reports.

Boston, Mass. Annual report, City Planning Board, 1919.

Medford, Mass. Annual report of Water and Sewer Commissioners for 1918.

New Bedford, Mass. Annual report of City Engineer for 1918.

Philadelphia, Pa. Annual report of Bureau of Surveys for 1918.

Providence, R. I. Annual report of City Engineer for 1918.

Miscellaneous.

American Railway Master Mechanics Association, Proceedings for 1917-1918.

American Society of Mechanical Engineers, Transactions for 1918.

Design of Steel Bridges. F. C. Kunz. 1915.

Graphical and Mechanical Computation. Joseph Lipka. 1918.

Industrial Building Book. C. F. Dingman. 1919.

Industrial Plants. C. T. Main. 1917.

Irrigation Engineering. A. P. Davis and H. M. Wilson. 1919.

Mechanical Equipment of Buildings. Vol. 1. Heating and Ventilating. Harding and Willard. 1917.

Meter Rates for Water Works. Allen Hazen. 1918.

The Turnpikes of New England. F. J. Wood. Gift of author. 1919.

Water Rights Determination. J. M. Whitman. 1918.

LIBRARY COMMITTEE.

Vol. VII FEBRUARY, 1920 No. 2

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PAPERS AND DISCUSSIONS

This Society is not responsible for any statement made or opinion expressed in its publications

MAXIMUM RATES OF PRECIPITATION AT BOSTON FOR VARIOUS FREQUENCIES OF OCCURRENCE.

By Harrison P. Eddy,* Past President Boston Society of Civil Engineers.

It has long been recognized that maximum rates of precipitation which are likely to prevail for given periods of time are of prime importance in the design of combined sewers and storm-water drains. The so-called rational method of design can only be applied by making use of figures for maximum rates of precipitation. It is therefore of great importance to have trustworthy data relative to the occurrence of excessive storms, giving the rates which have prevailed for various durations and the frequency at which such storms have recurred at any particular place, in order to make intelligent application of the rational method. Such a record is available at Boston for Chestnut Hill Reservoir, since 1879, and for the Weather Bureau station since 1891. The records have been worked up and the intensity and frequency curves computed for the periods ending with 1916, and therefore covering thirty-eight years at Chestnut Hill and twenty-six years for the Weather Bureau gage.

Sources of Information and Previous Studies.

The original record sheets of the Chestnut Hill Reservoir gage have kindly been placed at our disposal by Mr. William E.

* Of Metcalf & Eddy, 14 Beacon Street, Boston.

Note. This paper will not be presented at a regular meeting of the Society, but discussion is invited, to be received by W. L. Butcher, Editor, 715 Tremont Temple, Boston, before April 10, 1920, for publication in a subsequent issue of the Journal.

Foss, chief engineer of the Metropolitan Water Works, and the storms have been analyzed and tabulated by us.

The data obtained from the United States Weather Bureau gage at Boston are published in the annual reports of the chief of the Weather Bureau, beginning with that for the year 1895–1896, and in the Monthly Weather Review for the period since the publication of the last annual report.

Mr. E. S. Dorr, engineer of the Sewer Service of the City of Boston, studied the first fourteen years' record of the Chestnut Hill gage, and in the report of the Boston Street Department for 1892 published the result of his study and the mathematical formula for a rainfall curve to be used for sewer design in Boston. Mr. Charles W. Sherman, in a paper before the American Society of Civil Engineers, entitled "Maximum Rates of Rainfall at Boston," published in the Transactions of that Society, Volume 54, page 173, derived two curves, one for the maximum storms observed up to 1904, the other a suggested curve to be used in design of storm-water drains. Metcalf & Eddy's "American Sewerage Practice," Volume I, contains a further discussion of the data in that paper, with additional curves based upon the information therein — that is, for twenty-six years records of the Chestnut Hill gage. Emil Kuichling and Henry F. Bryant in a report upon the Adequacy of the Present Sewer System of the Back Bay District of Boston, made in 1909, discussed the data presented in Mr. Sherman's paper, together with the five additional years' records of the Chestnut Hill gage then available and the Weather Bureau records up to the same year, and offered another curve for use in design.

The several formulas suggested for representing rainfall curves are as follows (where i represents the intensity of precipitation in inches per hour, and t the duration in minutes):

$$i = \frac{150}{t+30} \text{ (Dorr, 1892).}$$

$$\text{Maximum } i = \frac{38.64}{t^{0.687}};\ i = \frac{25.12}{t^{0.687}} \text{ (Sherman, 1905).}$$

$$i = \frac{120}{t+20} \text{ (Kuichling, 1909).}$$

$$i = \frac{15.5}{t^{0.5}} \text{ (Metcalf \& Eddy, 1914).}$$

None of these equations was offered to represent rainfall for any definite degree of frequency. The subject of frequency is not discussed in any of the preceding articles, except in Metcalf & Eddy's "American Sewerage Practice," where curves of relative frequency are given, based upon the twenty-six years' record of the Chestnut Hill rain gage, but mathematical formulas were not suggested for any of these curves.

Intensity-frequency curves for Boston were prepared for United States Housing Corporation by Mr. E. P. Burke, under the direction of Prof. F. E. Turneaure, and published in *Engineering Contracting* for October 9, 1918, page 340.

Setting and Exposure of Automatic Rain Gage at Chestnut Hill Reservoir.

The automatic gage designed by Mr. Desmond FitzGerald, was described by him in *Engineering News* of May 31, 1884. In this description he notes that the collecting rim used was 14.85 ins. in diameter, — the same size as the standard water-works rain gage in which one ounce of rain collected represents 0.01 in. This rim was originally set "three feet above the roof of a small building at a height of 25 ft. above the ground, and bracketed out from the end of the building so as to give a fair exposure." In his paper entitled "Maximum Rates of Rainfall," in Transactions, Am. Soc. C. E., August, 1889, Mr. FitzGerald noted that in utilizing the recording gage records proper correction was applied for the elevated gage, due to its height above the ground:

"It is already a well-established fact that the higher we rise above the ground the less rain we can collect unless special construction is resorted to. . . . The receiver of the self-recording gage being placed on the roof of a small building about 25 ft. above the ground it becomes necessary to make the proper correction for altitude, which is done by taking the ratio of each storm in the upper gage to that in the ground gage and applying this percentage to any particular portion of the storm."

Later, the setting of this gage was changed, and in 1895 it was slightly above the ridge of the carpenter-shop roof, nearly over the center of the building, instead of being bracketed out



FIG. 1. CARPENTER SHOP ON WHICH RECORDING RAIN GAGE IS LOCATED, CHESTNUT HILL RESERVOIR.

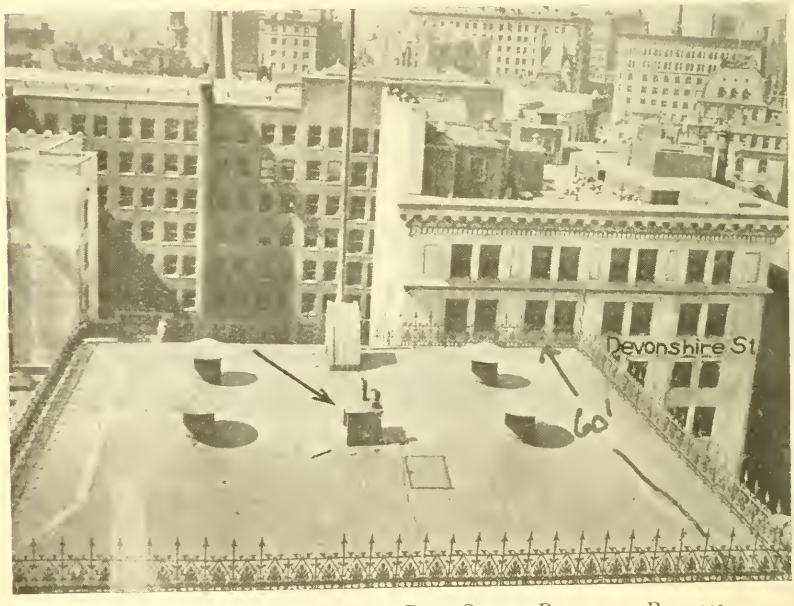


FIG. 2. RAIN GAGES ON ROOF OF POST-OFFICE BUILDING, BOSTON.

from the end as described above. It was about 25 ft. above the ground as previously. There was a platform around the gage, probably 4 or 5 ft. square, evidently built for the purpose of reducing as much as possible the effect of the pitch roof upon wind currents. (Fig. 1.)

The building on which the gage was located was in 1895 in the approximate location indicated upon the sketch (Plate I), and it is understood that this is the position in which it had been from the time the gage was established.

The distance from the ground gage was therefore about 450 ft. In 1898, when the low-service pumping station was constructed, it was necessary to move the carpenter shop to its present location, as shown upon the plan. The distance from the ground gage to the recording gage is now about 800 ft.

Setting and Exposure of Rain Gage at Boston Office, U. S. Weather Bureau.

The collector of the Marvin rain gage in use at this station is located on top of the westerly tower of the Post-Office Building. (Fig. 2.) This tower is about at the middle of the Devonshire Street side and 30 to 35 ft. lower than the easterly tower. The top of the tower is nearly flat and is surrounded by an iron picket fence The space inside the fence is 60 ft. square, and the cornice outside the fence is approximately $1\frac{1}{2}$ ft. wide. In the center of the roof is a wooden box upon which two rain gages are mounted, — one an ordinary non-registering gage, the other the collector of the Marvin gage from which electric wires lead to the recording instrument in the Weather Bureau office. The top of the Marvin gage collector is $5\frac{1}{2}$ ft. above the roof, and that of the other gage is about 6 ins. higher.

There are three or four large iron ventilators projecting above the roof to a height of about 4 ft., and also at the westerly side the covered exit from the stairs. The picket fence is $3\frac{1}{2}$ ft. high, with spikes at intervals, projecting 18 ins. higher.

The collector of the Marvin gage is surrounded by a screen or outer tube about $1\frac{1}{2}$ or 2 ins. outside the collector proper. Apparently even this small screen has been effective in overcoming the effect of wind currents and eddies around the gage.

Records of Chestnut Hill Reservoir Rain Gage. — The maximum intensities of rainfall for various periods of time at Chestnut Hill are given in Table 1. These intensities were computed from the original records. In preparing this table, all storms which appeared from an inspection of the charts to be of importance were included. In general it may be said that all storms of intensities equal to or greater than the following rates for specified periods were included.

5 min.	2.5 ins. per hour
10 min.	2.0 ins. per hour
15 min.	1.5 ins. per hour
20 min.	1.5 ins. per hour
30 min.	1.0 ins. per hour
45 min.	0.3 ins. per hour
60–180 min.	0.2 ins. per hour

Records from both gages were available for 144 storms. A comparison of the records of total precipitation for each entire storm, as obtained from the standard and recording gages, gave the following results:

	Storms.
Automatic gage record higher than standard gage record	16
Automatic gage record the same as standard gage record	8
Automatic gage record lower than standard gage record	120
Total	144

The range of the differences for these storms having a higher record by the automatic gage is 0.01 to 0.15 in. For the storms having a lower record by the automatic gage the range is 0.01 to 1.67 ins. There were 9 such storms, having a difference of 0.50 in. or more.

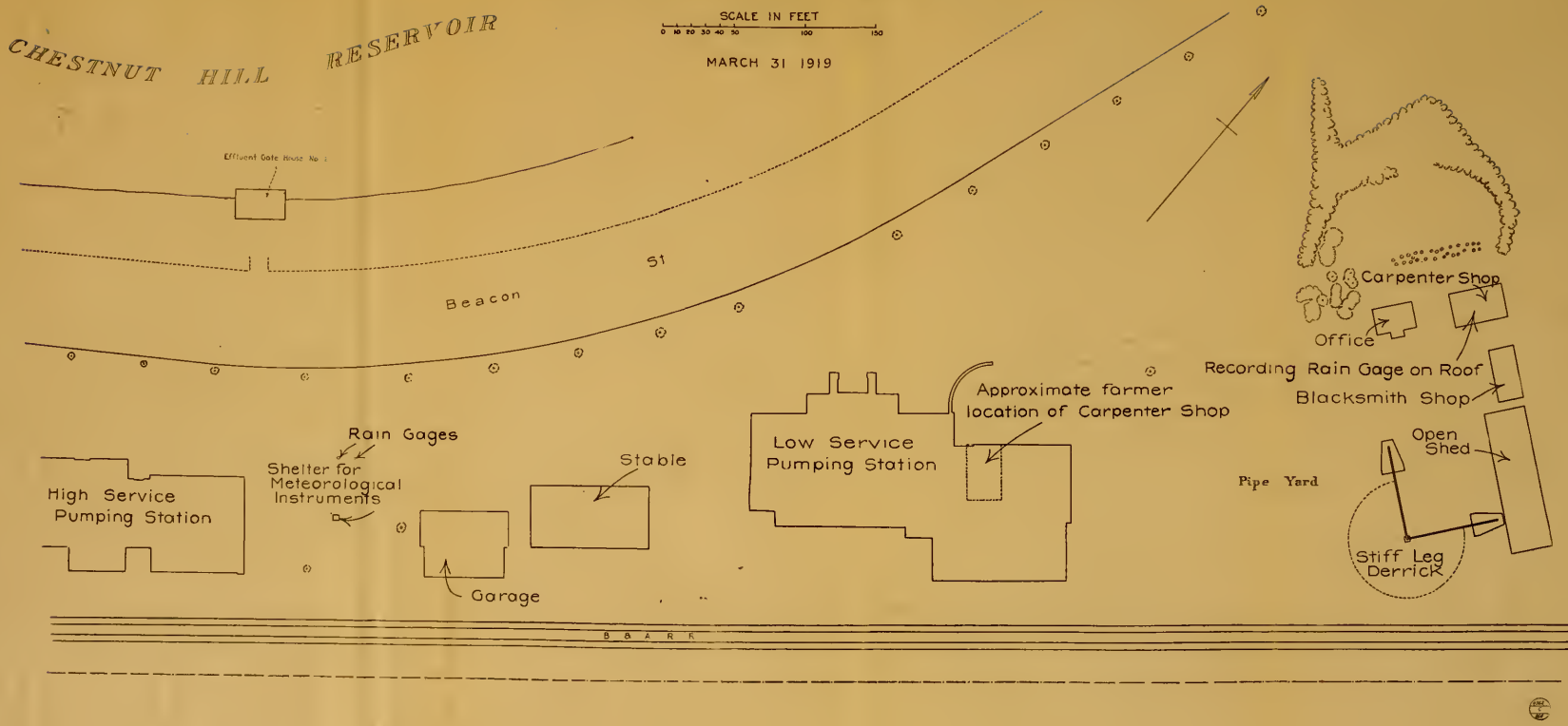
In the preparation of Table 1 it has been assumed that the standard gage gave the correct record and the rates indicated by the automatic gage have been corrected by applying a factor ascertained by comparison of the standard and automatic gage records. This factor was applied uniformly to the rates for all periods, notwithstanding that it was recognized that the correction might more properly be applied to some rates than to others in the same storm. However, no means are available for ascertaining which rates are most in error and what factors to apply to correct the several rates.

PLATE I.
JOURNAL BOSTON SOCIETY
OF CIVIL ENGINEERS.
FEBRUARY, 1920.
EDDY ON MAXIMUM RATES OF
PRECIPITATION.
LOCATION OF RAIN GAGES AT
CHESTNUT HILL.

SKETCH SHOWING LOCATION OF RAIN GAGES AT CHESTNUT HILL

SCALE IN FEET
0 10 20 30 40 50 100 150

MARCH 31 1919



Records of U. S. Weather Bureau Rain Gage. — As noted above, the records of this gage have been published in the annual reports of the chief of the Weather Bureau and in the Monthly Weather Review. The first publication, in the annual report for the year 1895–1896, is in somewhat different form than that employed in the later reports. In this case the precipitation for the maximum 5, 10 and 60 minutes of the storm was given, but not the progressive amounts for five-minute intervals, from the beginning of the excessive rate, which is the form followed in the later reports and in the Monthly Weather Review.

Table 2 contains the data relating to excessive storms at Boston as compiled from these several reports. The Weather Bureau classification includes as "excessive" storms those in which 0.25 in. fell in any five minutes, or 0.80 ins. in any hour. From Table 2 the maximum amounts for 5, 10, 15 minutes, etc., have been picked out, and the rates or intensities corresponding to these periods have been computed. The results are given in Table 3.

Frequency of Excessive Rates of Precipitation. — The intensities of precipitation given in Tables 1 and 3 have been plotted on diagrams showing the years of occurrence and the intensities for 5, 10, 20, 30, 45, 60, 80, 100, 120, 150 and 180 minutes, omitting points showing intensities which were so low that they had no effect in determining curves. These diagrams served as the first step for the construction of frequency curves; for instance, on the 38-year record of the Chestnut Hill gage the highest point for any duration obviously represented an intensity which occurred but once during the period, and therefore had a frequency of thirty-eight years. The second point represented an intensity which was equaled or exceeded twice, and therefore had an average frequency of nineteen years, etc.

As just stated, a frequency curve represents intensities which have not been equaled or exceeded on the average oftener than once in a certain number of years. It should be borne in mind, however, that such a curve may be equaled or exceeded by more than one storm during that period of years; for while on the average but one storm equaling or exceeding the curve will come within the period designated, two such storms on the

TABLE 1. — MAXIMUM INTENSITIES OF PRECIPITATION AT BOSTON (CHESTNUT HILL GAGE) FOR VARIOUS PERIODS DURING EXCESSIVE RATE.

Date.	Inches of Total Rainfall.		Maximum Average Intensity in Inches per Hour for the Time Stated.												
	Standard Gage.	Recording Gage.	5	10	15	20	25	30	45	60	80	100	120	150	180
1879															
June 29	1.41	1.07	4.27	3.01	2.11	1.98	1.90	1.74	1.55	1.19	0.91	0.74	0.67	...	...
July 16	...	0.72	4.20	3.36	2.56	1.95	1.59	1.32	0.93	0.42	...	...	...	...	...
Aug. 16–19	6.23	4.56	2.96	2.55	1.97	1.65	1.38	1.23	0.95	0.88	0.88	0.88	0.84	0.74	0.67
1880															
Apr. 16	0.77	0.72	1.29	0.96	0.86	0.71	0.64	0.60	0.43	0.34	0.30	0.28	0.25	...	...
July 20–21	1.99	1.73	5.52	4.83	4.14	3.56	3.03	2.72	1.94	1.50	1.23	1.04	0.83	...	...
1881															
Jan. 10	2.20	2.20	0.48	0.42	0.40	0.39	0.38	0.38	0.37	0.37	0.36	0.36	0.34	0.33	0.33
Feb. 12	1.55	1.44	0.91	0.71	0.61	0.52	0.47	0.43	0.42	0.36	0.35	0.35	0.35	0.31	0.27
June 10–11	3.83	3.50	0.65	0.65	0.65	0.62	0.60	0.59	0.55	0.52	0.51	0.51	0.50	0.48	0.45
July 21	0.48	0.36	4.63	2.71	1.92	...	...	...	...	...	...	...	...	...	...
Sept. 2–3	1.79	1.74	2.84	2.48	2.26	1.95	1.68	1.44	1.07	0.81	...	...	...	...	...
1882															
June 18	0.57	0.56	1.46	1.10	0.90	0.86	0.78	0.77	0.65	0.54	...	...	...	...	...
July 19	0.48	0.43	2.68	2.00	1.60	1.30	...	...	...	...	...	...	...	...	...
Sept. 11–12	3.00	2.35	1.38	1.15	0.92	0.81	0.74	0.69	0.51	0.49	0.41	0.41	0.40	0.33	0.34
Sept. 14	1.13	1.05	3.21	2.38	2.01	1.77	1.59	1.50	1.44	1.11	0.85	...	...	...	...
Sept. 21	1.13	1.10	1.86	1.24	1.03	0.83	0.72	0.62	0.51	0.48	0.42	0.36	0.30	0.25	0.23
Sept. 22–23	2.55	2.38	1.29	1.16	0.94	0.84	0.74	0.69	0.70	0.67	0.61	0.58	0.60	0.58	0.53
Sept. 24	0.44	0.41	1.28	1.09	0.94	0.77	0.63	0.54	0.44	0.34	...	...	...	...	...
1883															
Mar. 10	0.75	0.74	0.97	0.73	0.61	0.49	0.41	0.36	0.31	0.32	0.26	0.29	0.25	0.21	0.18
May 31	0.47	0.42	3.50	2.08	1.71	1.31	1.05	0.90	...	...	...	...	...	...	...
June 29	0.59	0.56	4.67	2.71	2.02	1.61	1.36	1.18	...	...	...	...	...	...	...
Nov. 26–27	1.51	1.39	0.92	0.79	0.61	0.62	0.60	0.52	0.48	0.39	0.34	0.37	0.34	0.30	0.29

1884															
June 19	1.66	1.55	3.59	3.02	2.45	2.19	1.87	1.85	1.51	1.33	1.10	0.88	0.75	0.63	0.54
June 25–26	2.76	2.56	2.33	1.82	1.39	1.17	1.06	1.00	0.82	0.69	0.59	0.52	0.46	0.41	0.37
July 18	1.19	1.14	9.12	4.93	3.41	...	...	...	...	...	...	...	...	...	...
Aug. 5–6	1.06	1.03	1.24	0.93	0.87	0.80	0.74	0.70	0.69	0.60	0.50	0.43	0.39	0.33	0.34
Aug. 7–8	2.14	1.97	1.18	0.98	0.87	0.85	0.81	0.76	0.74	0.61	0.47	0.42	0.41	0.35	0.39
1885															
June 28–29	1.26	1.15	1.31	1.24	1.09	1.05	0.97	0.92	0.93	0.86	0.76	0.64	0.54	0.45	0.38
June 29	1.17	1.05	3.33	2.79	2.44	1.97	1.71	1.51	1.13	0.94	0.72	0.62	0.52	0.44	0.38
July 29	0.81	0.76	1.92	1.73	1.41	1.35	1.26	1.11	0.86	0.69	0.55	0.44	0.39	...	...
Aug. 1	1.76	1.61	3.27	2.03	1.75	1.58	1.41	1.37	1.09	1.05	0.97	0.78	0.66	0.59	0.50
Oct. 2–3	1.25	1.18	3.55	2.04	1.48	1.21	1.02	1.02	0.88	0.72	0.56	0.46	0.40	0.33	0.29
1886															
July 15	1.74	1.59	3.27	2.36	1.62	1.24	1.10	1.13	0.95	0.83	0.73	...	...	...	...
1887															
July 10	1.10	0.99	2.39	2.20	1.82	...	...	...	...	...	...	...	...	...	...
July 22	1.16	0.97	1.59	1.37	1.20	1.19	1.10	1.01	0.96	0.83	0.68	0.61	0.55	0.45	0.38
July 23	0.67	0.60	1.34	1.21	0.99	1.01	0.86	0.76	0.64	0.50	0.41	0.33	...	...	...
1888															
May 13	1.32	1.22	1.69	1.31	1.08	1.13	1.11	1.00	0.88	0.69	0.67	0.63	0.59	0.51	0.43
Aug. 6	1.17	1.08	1.17	0.97	0.91	0.84	0.78	0.80	0.75	0.70	0.55	...	...	...	...
Aug. 12–13	1.73	1.60	2.07	1.88	1.73	1.62	1.55	1.51	1.37	1.13	0.89	0.75	0.67	0.57	0.49
Aug. 21–22	3.44	3.23	2.80	2.54	2.55	2.39	2.11	1.96	1.72	1.58	1.36	1.28	1.22	1.10	1.00
Sept. 10	1.35	1.30	1.85	1.42	1.24	1.05	0.94	0.83	0.74	0.70	0.62	0.56	0.53	0.47	0.42
Sept. 17–18	1.94	1.78	1.31	1.31	1.22	1.05	0.99	0.96	0.95	0.93	0.82	0.73	0.65	0.57	0.50
1889															
Apr. 26	1.66	1.31	1.68	1.15	0.91	0.76	0.70	0.67	0.54	0.48	0.44	0.39	0.37	0.39	0.37
May 20–21	3.17	3.19	1.67	1.36	1.35	1.28	1.23	1.15	0.85	0.89	0.69	0.58	0.62	...	...
June 2	1.59	1.55	2.22	1.86	1.52	1.27	1.14	1.03	0.91	0.75	0.69	0.61	0.55	0.45	0.44
June 5	0.47	0.47	2.64	1.62	1.12	...	...	...	...	...	...	...	...	...	...
July 17	0.75	0.68	3.97	3.32	2.16	1.72	...	...	...	...	...	...	...	...	...
Aug. 1	0.51	0.48	2.55	1.34	0.98	0.80	...	...	...	...	...	...	...	...	...
Aug. 14	1.60	1.51	2.55	1.78	1.32	1.02	0.81	0.68	0.47	0.39	0.36	0.30	0.26	0.21	...
Sept. 11	1.35	1.04	2.66	1.56	1.30	1.09	0.87	0.73	0.50	0.47	...	...	...	...	...
Sept. 18	2.23	2.03	1.98	1.52	1.32	1.32	1.19	1.10	0.95	0.83	0.67	0.54	0.47	0.40	0.34

TABLE 1, *Continued.* — MAXIMUM INTENSITIES OF PRECIPITATION AT BOSTON (CHESTNUT HILL GAGE) FOR VARIOUS PERIODS DURING EXCESSIVE RATE.

Date.	Inches of Total Rainfall.		Maximum Average Intensity in Inches per Hour for the Time Stated.												
	Standard Gage.	Recording Gage.	5	10	15	20	25	30	45	60	80	100	120	150	180
1890															
July 25	0.68	0.64	1.40	1.08	0.89	0.80	0.74	0.68	0.54	0.43	0.36	0.31	...	...	...
July 26	0.96	0.91	3.15	1.83	1.35	1.33	1.26	1.24	1.07	0.87	...	...	...	...	...
Aug. 6	0.31	0.34	3.28	1.69	...	...	...	...	...	...	...	...	...	...	...
Aug. 19	0.75	0.72	3.49	2.37	1.71	1.34	1.10	0.94	0.67	0.55	...	...	...	...	...
1891															
June 2	0.46	0.45	1.84	1.47	1.27	1.07	0.91	0.78	0.57	0.44	...	...	...	...	...
July 24	0.71	0.75	1.03	0.80	0.72	0.71	0.66	0.61	0.53	0.42	0.38	0.35	...	...	...
Sept. 5–7	2.83	2.55	3.20	2.66	2.36	2.13	1.89	1.78	1.61	1.39	0.71	...	...	...	...
Oct. 7–8	2.45	2.12	2.07	1.73	1.34	1.07	1.02	1.08	0.86	0.71	0.67	0.61	0.51	0.47	...
1892															
June 6	0.32	0.28	2.74	1.78	1.28	0.99	...	...	...	...	...	...	...	...	...
June 17	1.18	1.07	3.70	2.91	2.29	1.82	1.85	1.72	1.39	1.14	...	...	...	...	...
June 25	0.43	0.45	3.08	1.65	1.25	1.03	0.91	0.80	0.56	...	...	...	...	...	...
July 3	0.74	0.66	3.36	1.88	1.30	...	...	...	...	...	...	...	...	...	...
July 25	0.44	0.34	3.10	2.33	1.81	...	...	...	...	...	...	...	...	...	...
Aug. 12	2.19	2.17	3.76	2.97	2.79	2.43	2.38	2.42	1.85	1.57	1.23	1.02	0.85	0.69	...
1893															
July 18	0.73	0.73	1.32	1.26	1.20	1.17	1.15	1.14	0.97	...	...	...	...	...	...
Aug. 6–7	1.48	0.95	7.45	4.74	3.36	2.61	2.14	...	...	...	...	...	...	...	...
1894															
July 21	1.44	1.43	4.11	3.90	3.50	3.20	2.63	...	...	...	...	...	...	...	...
July 25	0.82	0.77	3.96	2.68	1.87	1.43	...	...	...	...	...	...	...	...	...
Aug. 20	1.40	1.42	3.55	2.96	2.56	2.12	2.01	1.80	1.35	1.07	0.88	0.74	0.64	0.53	0.45

1895															
May 27	0.30	0.28	1.29	0.96	0.73	0.61	0.54	0.49	0.36	...	...	...	...	...	...
June 1	0.29	0.27	2.59	1.73	1.20	...	...	...	...	...	...	...	...	...	...
July 9	1.31	1.26	1.75	1.37	1.25	1.13	0.92	0.83	0.74	0.66	0.59	...	...	...	...
July 30	0.63	0.63	0.96	0.60	0.48	0.45	0.41	0.40	0.40	0.40	0.41	0.36	...	...	...
Aug. 7	1.48	1.45	3.06	2.14	1.88	1.50	1.27	1.24	1.05	0.88	0.71	0.59	0.50	...	...
Aug. 18	1.17	1.20	3.82	2.62	2.13	1.89	1.68	1.51	1.10	0.88	0.69	0.59	0.52	0.43	...
Sept. 1	0.75	0.75	4.56	3.00	2.68	2.13	1.73	...	...	...	...	...	...	...	...
Oct. 31	2.86	2.43	1.14	0.92	0.85	0.89	0.85	0.85	0.80	0.71	0.73	0.69	0.66	0.64	0.61
Nov. 14–15	1.86	1.60	2.09	1.53	1.30	1.22	1.09	0.95	0.74	...	...	...	...	...	...
Nov. 26–27	1.25	1.04	1.15	1.01	0.86	0.79	0.72	0.62	0.48	0.46	0.43	0.37	0.32	...	...
1896															
July 15–16	0.93	0.65	1.91	1.44	1.26	1.07	0.93	0.80	0.55	...	...	...	...	...	...
Sept. 5–6	1.67	1.63	2.20	1.35	1.14	1.04	0.93	0.89	0.60	...	...	...	...	...	...
1897															
July 28	1.74	1.57	3.74	2.66	2.54	2.16	1.87	1.73	1.27	1.09	0.88	0.76	0.67	0.57	0.48
Aug. 22	0.62	0.66	2.26	1.62	1.80	1.55	1.29	...	...	...	...	...	...	...	...
Sept. 13	0.34	0.33	0.99	0.74	0.70	0.62	0.62	0.58	0.45	0.35	...	...	...	...	...
Sept. 20	0.98	1.00	3.30	2.35	2.00	1.71	1.44	1.25	0.90	0.72	0.56	0.46	...	...	...
1898														...	...
July 4	0.75	0.81	3.46	2.52	2.12	1.70	1.45	1.27	...	...	...	...	...	...	...
July 21	0.57	0.57	1.20	1.08	0.92	0.78	0.72	0.66	0.61	0.52	...	...	...	0.41	0.38
Oct. 26–27	1.76	1.51	1.69	1.26	0.89	0.77	0.79	0.77	0.75	0.68	0.58	0.53	0.47		
1899															
Aug. 22	2.33	2.27	7.42	6.30	5.77	4.62	3.85	3.53	2.50	2.02	1.74	...	...	...	...
Sept. 20	3.34	3.18	2.27	1.89	1.81	1.64	1.49	1.39	1.29	1.21	1.14	1.14	...	...	...
1900															
Sept. 17	2.02	1.80	1.21	0.94	0.81	0.77	0.75	0.69	0.66	0.65	0.64	0.60	0.58	0.53	...
Sept. 21–22	0.47	0.43	1.31	0.91	0.78	0.72	0.63	0.57	0.44	...	...	...	...	...	...
Nov. 9	0.49	0.47	2.50	1.75	1.29	1.03	0.85	0.73	0.53	0.47	...	...	...	...	...
1901															
July 29	2.10	1.90	1.71	1.58	1.41	1.29	1.21	1.14	0.95	0.88	0.85	0.74	0.64	0.58	0.53
Aug. 7	1.45	1.43	3.70	2.24	1.54	1.24	1.21	1.09	0.82	0.64	...	...	...	...	...
Aug. 25	2.10	2.20	4.56	3.54	3.42	2.96	2.60	2.30	2.03	1.78	1.41	...	...	...	...
1904															
July 5	0.44	0.44	1.80	1.08	0.76	0.60	0.55	0.50	0.45	0.38	0.32	...	...	...	...
Sept. 14–15	3.84	3.78	1.84	1.71	1.43	1.28	1.17	1.06	0.84	0.70	0.58	0.58	0.59	0.53	0.49

TABLE 1, *Continued.* — MAXIMUM INTENSITIES OF PRECIPITATION AT BOSTON (CHESTNUT HILL GAGE) FOR VARIOUS PERIODS DURING EXCESSIVE RATE.

Date.	Inches of Total Rainfall.		Maximum Average Intensity in Inches per Hour for the Time Stated.												
	Standard Gage.	Recording Gage.	5	10	15	20	25	30	45	60	80	100	120	150	180
1905															
June 12–13	1.60	1.25	2.76	2.54	2.56	2.30	...	...	...	...	...	...	...	...	...
July 14	0.82	0.77	2.80	1.65	1.36	1.05	...	...	...	...	...	...	...	...	...
Aug. 12	1.06	1.08	3.53	2.94	2.36	2.06	1.67	1.39	1.05	0.97	...	...	...	...	...
Sept. 2–4	5.24	4.87	2.08	1.36	1.17	0.97	0.80	0.89	0.73	0.72	0.67	0.59	0.59	0.52	0.45
1906															
Mar. 4	2.63	2.39	3.17	1.85	1.28	1.03	0.85	0.77	0.66	0.59	0.50	0.49	0.44	0.42	0.40
May 27–29	3.89	3.34	0.97	0.77	0.70	0.63	0.59	0.58	0.54	0.51	0.50	0.45	0.42	0.37	0.33
June 30–July 1	1.71	1.53	1.08	0.87	0.81	0.90	0.62	0.56	0.54	0.52	0.47	0.47	0.44	0.40	0.35
Aug. 27	0.72	0.67	2.72	2.14	1.64	1.30	1.06	0.90	0.62	0.50	0.44	0.36	0.32	0.28	0.25
1907															
June 29–30	1.09	0.98	1.07	0.87	0.84	0.80	0.80	0.77	0.59	0.50	0.50	0.43	0.40	0.34	0.29
Sept. 2–4	3.34	2.84	2.84	2.27	2.03	2.05	1.84	1.65	1.32	1.07	0.88	0.83	0.74	0.61	0.53
Sept. 4–5	3.34	2.84	2.55	1.58	1.56	1.35	1.36	1.32	1.23	0.97	0.83	0.71	0.60	...	...
Sept. 21	0.23	0.24	1.12	1.09	0.77	0.44	0.33	...	...	...	...	...	...	...	...
Sept. 22–24	2.35	2.04	1.65	1.24	1.01	0.96	0.86	0.74	0.60	0.54	0.44	0.41	...	...	...
Oct. 8	1.67	1.11	3.24	2.25	1.74	1.44	1.22	1.05	0.76	0.60	...	...	...	...	...
Nov. 3	0.95	0.74	1.69	1.39	1.18	1.08	0.95	0.87	0.82	0.64	...	...	...	...	...
1908															
Sept. 27	1.09	0.86	2.13	1.37	1.02	0.80	0.70	0.61	0.57	0.50	0.40	0.33	0.29	0.23	...
Oct. 26	1.42	1.23	1.79	1.11	0.87	0.70	0.64	0.51	0.40	0.31	0.25	0.26	0.24	0.24	0.23
1909															
June 13	0.89	0.76	1.40	0.98	0.84	0.70	0.65	0.68	0.62	0.54	0.58	0.49	0.42	...	...
Sept. 23	0.91	0.83	2.65	1.89	1.58	1.29	1.16	1.06	0.75	0.56	...	...	...	...	...
Nov. 24–26	3.44	2.95	0.70	0.55	0.46	0.45	0.47	0.44	0.45	0.43	0.42	0.42	0.42	0.38	0.38

1910															
June 9–12	3.40	2.85	3.00	2.14	2.05	1.79	1.77	1.53	1.33	1.05	...	...	...	...	...
July 25	0.51	0.47	1.81	1.55	1.51	1.23	...	...	...	...	...	...	...	...	...
1911															
June 5–7	2.58	2.43	0.40	0.40	0.36	0.37	0.35	0.36	0.33	0.32	0.32	0.34	0.31	0.31	0.27
July 28	3.65	3.80	1.73	1.15	1.15	1.09	0.99	0.98	0.86	0.87	0.81	0.78	0.72	0.66	0.62
Aug. 15	0.51	0.47	2.21	1.23	0.87	0.71	0.60	0.54	0.40	0.31	...	...	...	...	...
Aug. 18	0.48	0.49	1.18	0.88	0.74	0.62	0.54	0.49	0.36	0.31	0.28	0.25	...	...	...
Aug. 29–30	1.32	1.27	2.12	1.56	1.46	1.25	1.03	0.87	0.60	0.48	0.40	0.36	0.32	...	...
Sept. 25–26	1.58	1.56	4.24	3.40	3.03	2.79	2.79	2.62	1.92	...	...	...	...	...	...
1912															
July 11	1.05	1.06	2.14	1.73	1.67	1.60	1.47	1.43	1.30	1.04	...	...	...	...	...
Aug. 11	0.45	0.41	1.19	0.92	0.92	0.92	0.90	0.79	0.54	...	...	...	...	...	...
1913															
July 28	0.66	0.65	1.46	1.21	1.17	1.03	0.94	0.81	0.62	0.51	0.46	0.38	...	...	...
Aug. 2	0.67	0.67	1.56	1.26	0.96	1.05	1.03	0.98	0.75	0.58	0.45	...	...	...	...
Aug. 13	0.80	0.69	3.77	2.44	1.86	1.50	1.26	1.11	0.82	0.75	.059	...	...	...	...
Aug. 18	0.95	0.82	3.35	2.95	2.79	2.30	1.95	1.70	1.27	0.95	...	...	...	...	...
Aug. 27	0.44	0.42	2.52	2.21	1.68	1.33	1.06	...	...	...	...	...	...	...	...
Oct. 19–20	1.60	1.54	1.87	1.25	1.08	1.09	1.03	0.94	0.90	0.76	0.64	...	...	...	...
Nov. 4–9	0.79	0.66	2.45	1.80	1.54	1.26	1.02	0.84	...	...	...	...	...	...	...
1914															
Aug. 19–20	1.00	1.10	1.86	1.20	0.87	0.68	0.66	0.71	0.64	0.57	0.49	0.41	0.36	0.31	0.26
Aug. 20–21	0.76	0.75	2.55	1.88	1.37	1.09	0.90	0.75	0.57	0.50	0.39	...	...	...	...
1915															
June 30–July 3	6.42	5.53	2.37	2.09	1.90	1.81	1.81	1.74	1.62	1.57	1.45	1.43	1.28	1.11	1.01
July 5	0.46	0.43	2.96	1.80	1.41	1.09	0.90	0.77	...	...	...	...	...	...	...
Aug. 4–7	2.61	2.50	2.12	1.62	1.46	1.47	1.35	1.25	1.12	1.02	0.93	0.86	0.79	0.70	0.63
Aug. 9	0.51	0.47	2.47	1.68	1.38	1.10	0.91	0.76	...	...	...	...	...	...	...
Aug. 13	0.94	0.87	1.81	1.36	1.25	1.07	0.91	0.82	0.62	0.50	...	...	...	...	...
Sept. 21	0.81	0.76	2.04	1.42	1.20	1.12	1.08	1.05	0.78	0.64	0.51	...	...	...	...
1916															
June 16–17	2.04	1.70	2.02	1.87	1.92	1.62	1.44	1.27	0.88	0.78	0.69	0.58	0.57	0.48	0.43
Aug. 8	0.42	0.41	2.57	2.02	1.55	...	...	...	...	...	...	...	...	...	...

TABLE 2. — Excessive Precipitation at Boston from Records of

Date.	Storm.		Total Precip. Ins.	Excessive Precipitation.		Amt. Before Excess Rate Began.
	Began.	Ended.		Began.	Ended.	
1891						
July 4						
1892						
June 25						
July 3						
Aug. 12	12.05a.	1.35a.	1.47			
1893						
May 3–4						
Aug. 6	6.09p.	6.29p.	1.00			
1894						
July 21						
July 25						
Aug. 20	12.32p.	1.32p.	1.68			
1895						
July 14						
Aug. 18						
Oct. 12–13						
1897						
July 29	D. N.	10.05a.	1.48	6.27a.	8.27a.	0.16
Aug. 4	4.38p.	5.14p.	0.58	4.50p.	5.10p.	0.04
Aug. 24	8.45a.	1.40p.	1.45	12.40p.	1.28p.	0.58
Sept. 20	3.37p.	6.25p.	0.70	4.35p.	5.00p.	0.09
1898						
July 4	4.00p.	5.03p.	0.48	4.37p.	4.51p.	0.06
Aug. 17	4.50p.	7.25p.	1.03	5.00p.	5.35p.	T
Sept. 7	5.00p.	7.30p.	0.55	6.50p.	7.00p.	0.03
1899						
Aug. 22	6.05a.	7.30p.	1.38	6.09p.	7.20p.	T
Sept. 20	4.00a.	12.30p.	2.82	7.20a.	9.20a.	0.67
1900						
July 25	5.30p.	8.15p.	0.50	5.32p.	5.42p.	T
Aug. 16	3.10a.	12.55p.*	1.04	12.10p.	12.30p.	0.50
1901						
Aug. 24–25	6.35p.	D. N.	2.08	11.20p.	12.25a.	0.21
1902						
Aug. 11	1.00p.	3.00p.	0.85	1.14p.	1.45p.	T
1903						
June 20–21	5.30p.	11.50p.	2.51	3.25p.	3.50p.	1.29
Oct. 17–18	1.05p.	6.50a.	2.58	2.58p.	3.18p.	0.09
1904						
Aug. 2	5.20a.	8.20a.	0.54	5.23a.	5.38a.	T
Sept. 14–15	9.40p.	9.30a.	3.48	6.05a.	7.50a.	1.53
1905						
June 19	3.15a.	11.10a.	0.93	8.05a.	8.30a.	0.28
June 26	2.44p.	3.15p.	0.78	2.49p.	2.59p.	T
Aug. 12	11.45a.	12.50p.	1.26	11.47a.	12.45p.	T

* See annual reports of chief of Weather Bureau, and Monthly Weather Review.

U. S. Weather Bureau, 1891–1916, Inclusive.*

Cumulative Precipitation (Ins.) in Successive Periods during Excessive Rate.

	5	10	15	20	25	30	35	40	45	50	60	80	100	120	150
1891															
July 4	.40†	.47†	...	...	...	...	...	...	...	...	0.54†	...	...	...	...
1892															
June 25	.30†	.35†	...	...	...	...	...	...	...	...	0.45†	...	...	...	...
July 3	.25†	.28†	...	...	...	...	...	...	...	...	0.42†	...	...	...	...
Aug. 12	.05	.40	.85	0.88	0.90	1.15	1.35	1.44	1.47	...		...	...	...	...
1893															
May 3–4				Out	of o	rder									
Aug. 6	.03	.21	.53	0.88	1.00	...	...	...	...	...		...	...	...	...
1894															
July 21	.35†	.50†	...	...	...	...	...	...	...	...	0.73†	...	...	...	...
July 25	.29†	.37†	...	...	...	...	...	...	...	...	0.39†	...	...	...	...
Aug. 20	.05	.12	.23	0.33	0.86	1.19	1.43	1.60	1.63	1.66	1.68	...	...	...	...
1895															
July 14	.27†	.33†	...	...	...	...	...	...	...	...	0.33†	...	...	...	...
Aug. 18	.29†	.38†	...	...	...	...	...	...	...	...	0.93†	...	...	...	...
Oct. 12–13	.10†	.19†	...	...	...	...	...	...	...	...	0.70†	...	...	...	...
1897															
July 29	.30	.39	.45	0.49	0.52	0.62	0.68	0.77	0.78	0.99	1.04	1.12	1.17	1.22	...
Aug. 4	.06	.23	.46	0.53	...	...	...	...	...	...		...	...	...	...
Aug. 24	.03	.07	.24	0.42	0.53	0.57	0.61	0.71	0.82	0.85		...	...	...	...
Sept. 20	.05	.12	.24	0.41	0.47	...	...	...	...	...		...	...	...	...
1898															
July 4	.04	.24	.40	0.42	...	...	...	...	...	...		...	...	...	...
Aug. 17	.05	.22	.26	0.29	0.63	0.89	0.93	...	...	...		...	...	...	...
Sept. 7	.20	.36	...	...	...	...	...	...	...	...		...	...	...	...
1899															
Aug. 22	.22	.43	.85	1.06	1.11	1.13	1.15	1.16	1.18	1.21	1.24	1.37	...	...	...
Sept. 20	.07	.15	.23	0.30	0.35	0.39	0.48	0.57	0.61	0.65	0.70	0.94	1.19	1.63	...
1900															
July 25	.30	.35	.36	...	...	...	...	...	...	...		...	...	...	...
Aug. 16	.15	.35	.51	0.54	...	...	...	...	...	...		...	...	...	...
1901															
Aug. 24–25	.07	.13	.26	0.35	0.53	0.72	0.89	1.24	1.33	1.43	1.76	1.90	...	...	...
1902															
Aug. 11	.10	.26	.38	0.50	0.63	0.70	0.71	...	...	...		...	...	...	...
1903															
June 20–21	.08	.22	.38	0.46	0.51	0.54	0.56	...	...	...		...	...	...	...
Oct. 17–18	.23	.41	.43	0.48	...	...	...	...	...	...		...	...	...	...
1904															
Aug. 2	.14	.36	.38	...	...	...	...	...	...	...		...	...	...	...
Sept. 14–15	.07	.08	.17	0.23	0.30	0.41	0.44	0.49	0.59	0.74	0.92	1.30	1.59	1.73	...
1905															
June 19	.18	.31	.39	0.47	0.52	...	...	...	...	...		...	...	...	...
June 26	.39	.72	.75	...	...	...	...	...	...	...		...	...	...	...
Aug. 12	.06	.16	.27	0.56	0.77	0.78	0.83	0.84	0.94	1.05	1.26	...	...	...	...

† Maximum for period of this length.

TABLE 2, *Continued.* — EXCESSIVE PRECIPITATION AT BOSTON FROM RECORDS OF

Date.	Storm.		Total Precip. Ins.	Excessive Precipitation.		Amt. before Excess Rate Began.
	Began.	Ended.		Began.	Ended.	
1906						
July 10	3.37p.	5.50p.	1.12	3.47p.	4.22p.	T
July 30	12.10a.	8.15a.	1.36	2.48a.	3.32a.	0.09
Oct. 9	8.18p.	D. N.	1.96	9.02p.	10.02p.	0.05
1907						
Sept. 5	8.45a.	3.10p.	1.03	1.25p.	2.11p.	0.27
Oct. 8	D. N.	1.45p.	1.14	10.33a.	10.48a.	0.60
1908						
Aug. 7	1.38p.	4.45p.	1.73	1.48p.	2.33p.	T
1910						
June 12	12.30a.	7.45a.	0.89	2.23a.	2.47a.	0.15
July 25	4.45p.	5.40p.	0.33	5.06p.	5.15p.	T
1911						
June 13	12.40p.	5.15p.	1.09	3.40p.	4.37p.	0.13
July 28	2.45a.	6.30p.	3.49	11.10a.	12.53p.	1.08
Sept. 25	5.40p.	7.55p.	1.05	5.50p.	6.25p.	T
1912						
July 18	3.15p.	7.00p.	1.70	4.18p.	5.22p.	0.08
1913						
July 30	1.26p.	2.03p.	0.91	1.28p.	1.53p.	T
Aug. 27	12.57p.	1.50p.	0.78	1.07p.	1.27p.	T
1915						
July 1	2.00a.	7.30a.	3.37	3.53a.	6.43a.	0.35
Aug. 4–5	10.30a.	6.00p.	2.28	2.40p.‡	4.00p.‡	0.65
1916						
July 3	3.55p.	6.15p.	1.71	4.34p.	5.05p.	0.17

* See annual reports of chief of Weather Bureau, and Monthly Weather Review.
‡ August 4.

average will come during two such periods, but both may come within one such period without affecting the average frequency. Such a curve may also be exceeded by several storms, because the intensity curve is based on and covers many periods and several storms. For example, the 5-minute period of the curve may be based on one storm, the 10- to 30-minute period on another and the 30- to 120-minute period upon a third.

In the same way the curve may be exceeded by one storm for a 5-minute period, by another for a 10- to 30-minute period, and by a third for a 30- to 120-minute period. Such a curve would have been exceeded by three storms, but no point of the curve would have been exceeded by more than one storm.

U. S. Weather Bureau, 1891–1916, Inclusive.*

Cumulative Precipitation (Ins.) in Successive Periods during Excessive Rate.

	5	10	15	20	25	30	35	40	45	50	60	80	100	120	150
1906															
July 10	.07	.20	.33	0.61	0.75	0.77	0.96	...	...	...		...	...	...	...
July 30	.05	.10	.16	0.24	0.28	0.33	0.49	0.59	0.67	...		...	...	...	...
Oct. 9	.11	.24	.40	0.56	0.67	0.86	0.95	1.10	1.26	1.45	1.58	...	...	...	...
1907															
Sept. 5	.05	.17	.25	0.33	0.42	0.52	0.61	0.66	0.72	...		...	...	...	...
Oct. 8	.17	.31	.35	...	...	...	...	...	...	...		...	...	...	...
1908															
Aug. 7	.07	.11	.23	0.57	1.13	1.30	1.52	1.54	1.62	...		...	...	...	...
1910															
June 12	.09	.32	.40	0.47	0.52	...	...	...	...	...		...	...	...	...
July 25	.24	.30	...	...	...	...	...	...	...	...		...	...	...	...
1911															
June 13	.12	.31	.37	0.44	0.55	0.63	0.68	0.70	0.72	0.75	0.88	...	...	...	...
July 28	.06	.14	.19	0.22	0.20	0.30	0.37	0.41	0.48	0.53	0.70	1.16	1.33	1.55	...
Sept. 25	.20	.41	.62	0.74	0.92	1.01	...	...	...	...		...	...	...	...
1912															
July 18	.11	.21	.37	0.48	0.59	0.77	0.95	1.11	1.30	1.36	1.52	1.59	...	...	...
1913															
July 30	.13	.42	.56	0.76	0.91	...	...	...	...	...		...	...	...	...
Aug. 27	.31	.42	.67	0.77	...	...	...	...	...	...		...	...	...	...
1915															
July 1	.09	.13	.19	0.26	0.35	0.46	0.59	0.70	0.80	1.00	1.20	1.54	1.89	2.25	2.81
Aug. 4–5	.10	.16	.24	0.32	0.40	0.45	0.51	0.60	0.69	0.77	0.90	1.17	...	...	...
1916															
July 3	.28	.50	.72	1.13	1.18	1.33	1.34	...	...	...		...	...	...	...

Comparison of Chestnut Hill and Weather Bureau Frequency Curves. — It has already been noted that the Weather Bureau recording gage was established in 1891, or twelve years later than the Chestnut Hill Reservoir gage. In order to compare the rainfall at the two stations, the records covering the period from 1891 to 1916 have been worked up separately for each station. The frequencies corresponding to various intensities have been plotted and smooth curves constructed for each of the stations. These frequency curves are reproduced on Fig. 3, and coördinates taken from the curves are tabulated in Table 4.

A study of Fig. 3 and Table 4 shows that there are material differences between the several curves for the two stations. The 26-year frequency curve for Chestnut Hill station is continu-

TABLE 3. — MAXIMUM INTENSITIES OF PRECIPITATION AT BOSTON (WEATHER BUREAU GAGE) FOR VARIOUS PERIODS DURING EXCESSIVE RATES.

Date.	Maximum Average Intensity in Inches per Hour for the Time Stated in Minutes.													
	5	10	15	20	25	30	35	40	45	50	60	80	100	120
1891														
July 4	4.80	2.82									0.54			
1892														
June 25	3.60	2.10									0.45			
July 3	3.00	1.68									0.42			
Aug. 12*	6.00	4.80	3.40	2.64	2.64	2.60	2.38	2.16	1.96		1.50			
1893														
Aug. 6	4.44	4.20	3.56	2.91	2.40					1.24				
1894														
July 21	4.20	3.00												
July 25	3.48	2.22							0.97					
Aug. 20†	6.72	4.98	4.40	3.81	3.29	2.96	2.66	2.40	2.17	2.00	1.68			
1895														
July 14	3.24	1.98												
Aug. 18	3.48	2.28									0.93			
Oct. 12–13‡	1.20	1.14									0.70			
1897														
July 29	3.60	2.34	1.80	1.47	1.25	1.24	1.17			1.17	1.04	0.84	0.70	0.64
Aug. 4	2.66	2.40	1.88	1.59										
Aug. 24	2.16	2.10	1.84	1.50	1.30									
Sept. 20	2.04	1.74	1.40	1.26	1.13									
1898														
July 4	2.40	1.96	1.60	1.26										
Aug. 17	4.08	3.60	2.56	2.01	2.01	1.78	1.60							
Sept. 7	2.40	1.96												

1899														
Aug. 22	4.92	3.78	3.36	3.18	2.67	2.26	1.98	1.74	1.57	1.45	1.24	1.03		
Sept. 20	1.80	1.38		1.32				1.04			0.98			0.82
1900														
July 25	3.60	2.10	1.44											
Aug. 16	2.40	2.16	2.04	1.62										
1901														
Aug. 24–25	4.20	3.12	2.84	2.67	2.35	2.16		2.19	2.00	1.96	1.76	1.43		
1902														
Aug. 11	1.92	1.68	1.60	1.59	1.51	1.40	1.22							
1903														
June 20–21	1.92	1.80	1.52	1.38	1.23	1.08	0.96							
Oct. 17	2.76	2.46	1.72	1.44										
1904														
Aug. 2	2.64	2.16	1.52											
Sept. 14–15		2.28	2.24	2.13	1.94	1.72	1.53	1.50	1.46	1.38	1.30	1.20	1.04	
1905														
June 19	2.16	1.86	1.56	1.41	1.25									
June 26	4.68	4.32	3.00											
Aug. 12	3.48	3.00	2.44	2.13	1.85	1.56	1.42	1.34	1.32	1.26	1.26			
1906														
July 10	3.36	2.52	2.20	2.04	1.82	1.78	1.65							
July 30	1.92	1.56	1.36	1.17	1.04	1.02	0.98	0.93	0.89					
Oct. 9	2.28	2.10	2.00		1.88			1.82	1.78	1.74	1.58			
1907														
Sept. 5	1.44	1.20			1.13	1.12	1.05	1.01	0.96					
Oct. 8	2.04	1.86	1.40											
1908														
Aug. 7	6.72	5.40	4.28	3.87	3.38	2.90	2.60	2.30	2.16					
1910														
June 12	2.76	1.92	1.60	1.41	1.25									
July 25	2.88	1.80												

* 0.38 for 4 hours. † 0.54 for 4 hours. ‡ 0.15 for 38 hours.

TABLE 3, *Continued.* — MAXIMUM INTENSITIES OF PRECIPITATION AT BOSTON (WEATHER BUREAU GAGE) FOR VARIOUS PERIODS DURING EXCESSIVE RATE.

Date.	Maximum Average Intensity in Inches per Hour for the Time Stated in Minutes.													
	5	10	15	20	25	30	35	40	45	50	60	80	100	120
1911														
June 13	2.28	1.86	1.48	1.32	1.32	1.26	1.17	1.05	0.96	0.90	0.88			
July 28				1.38		1.26	1.17	1.13	1.05	1.03	0.94	0.87	0.80	0.78
Sept. 25	2.52	2.52	2.48	2.22	2.21	2.02								
1912														
July 18	2.16	2.16		2.13	1.97	1.88	1.88	1.79	1.73	1.63	1.52	1.20		
1913														
July 30	3.48	2.58	2.52	2.34	2.18									
Aug. 27	3.72	2.52	2.68	2.31										
1915														
July 1§	2.40	1.80	1.64	1.62	1.56	1.52	1.46	1.41	1.34	1.28	1.21	1.21	1.21	1.18
Aug. 4–5	1.20	0.96	0.96	0.96	0.96	0.92	0.92	0.92	0.92	0.92	0.90	0.88		
1916														
July 3	4.92	3.78	3.40	3.39	2.84	2.66	2.30							

§ 1.60 for 170 minutes.

ously higher than that for the Weather Bureau station, the differences being much more marked for the shorter than for the longer periods. Likewise the 20-year frequency curve for Chestnut Hill station is continuously higher than that for the Weather Bureau station. The 15-year curves cross twice, the Chestnut Hill station curve being higher for the 5-minute period and for the 60-, 80-, 100- and 120-minute periods, and lower for the 10-,

TABLE 4. — Coördinates of Precipitation Curves of Various Frequencies, according to the Chestnut Hill and Weather Bureau Records, Boston, Mass., Twenty-Six Years, 1891–1916, Inclusive.

Duration. (Min.)	Maximum — 26 Years.		Frequency — 20 Years.		Frequency — 15 Years.	
	Intensity at		Intensity at		Intensity at	
	Chestnut Hill.	Weather Bureau.	Chestnut Hill.	Weather Bureau.	Chestnut Hill.	Weather Bureau.
5	7.50	6.70	7.40	6.70	7.40	6.70
10	6.43	5.46	5.70	5.38	5.13	5.15
15	5.50	4.47	4.63	4.41	3.98	4.30
20	4.68	3.92	3.98	3.85	3.38	3.77
30	3.58	3.02	3.15	2.98	2.77	2.93
45	2.55	2.30	2.32	2.20	2.15	2.17
60	2.04	1.75	1.93	1.72	1.80	1.69
80	1.70	1.40	1.58	1.35	1.48	1.30
100	1.45	1.22	1.32	1.13	1.19	1.07
120	1.28	1.12	1.12	0.99	0.95	0.86

Duration. (Min.)	Frequency — 10 Years.		Frequency — 5 Years.	
	Intensity at		Intensity at	
	Chestnut Hill.	Weather Bureau.	Chestnut Hill.	Weather Bureau.
5	5.35	6.23	4.15	4.90
10	4.22	4.95	3.45	4.12
15	3.52	4.02	2.87	3.43
20	3.02	3.47	2.48	2.85
30	2.49	2.75	1.98	2.27
45	2.01	2.06	1.57	1.79
60	1.70	1.62	1.33	1.44
80	1.35	1.22	1.09	1.04
100	1.05	0.95	0.88	. . .
120	0.84	0.74	0.73	. . .

TABLE 4, *Continued.*

Duration. (Min.)	Frequency — 3 Years.		Frequency 2 Years.	
	Intensity at		Intensity at	
	Chestnut Hill.	Weather Bureau.	Chestnut Hill.	Weather Bureau.
5	3.80	4.24	3.68	3.58
10	3.03	3.38	2.88	2.83
15	2.54	2.75	2.40	2.31
20	2.20	2.34	2.05	1.95
30	1.76	1.85	1.60	1.57
45	1.33	1.43	1.24	1.18
60	1.07	1.15	1.01	0.88
80	0.88	0.83	0.82	...
100	0.75	...	0.67	...
120	0.64	...	0.57	...

15-, 20-, 30- and 45-minute periods. The 10-year frequency curve for Chestnut Hill station is lower for periods of from 5 to 45 minutes and higher for periods of from 60 to 120 minutes. The 5-year curve for the Weather Bureau station is continuously the higher until the 80-minute period is reached. The Weather Bureau curve is continuously the higher for the 3-year frequency, and for the 2-year frequency the Chestnut Hill curve is the higher.

On the whole, the curves of the two stations are as nearly coincident as can be expected, as there are several causes for differences. Among these, perhaps the most important are the relative elevations of the gages above the ground, that at Chestnut Hill being 25 ft. and that of the Weather Bureau 150 ft. above the ground. At Chestnut Hill the recording gage is checked with a standard gage 1 ft. above the ground. This is not done at the Weather Bureau. The corrections at Chestnut Hill are substantial in amount although they are applied uniformly throughout the storm, while in fact they probably should vary more or less proportionately to the rates of precipitation. It is probable that these errors and corrections apply in greater measure to the periods of high intensity than to those of moderate intensity; that is, to very intense storms and to the periods

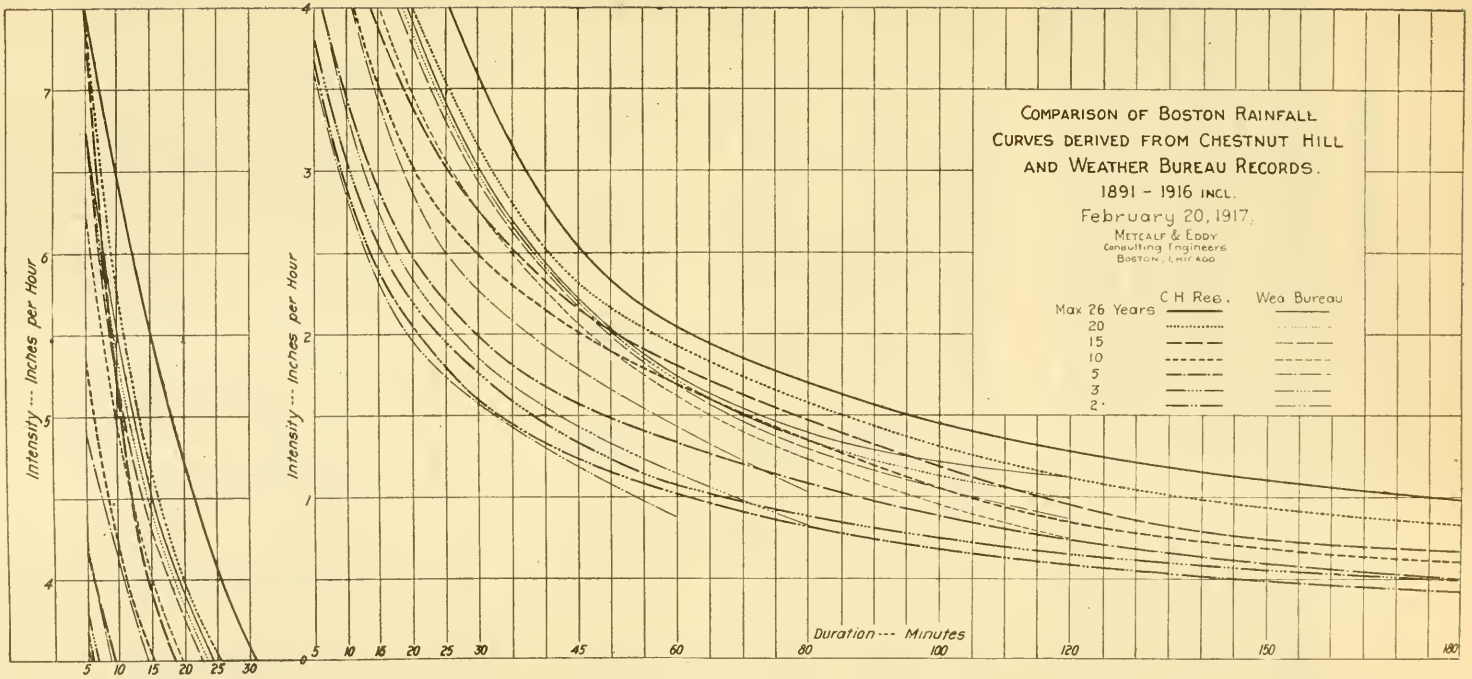

Comparison of Boston Rainfall
Curves derived from Chestnut Hill
and Weather Bureau Records.
1891 - 1916 incl.
February 20, 1917.
Metcalf & Eddy
Consulting Engineers
Boston, Chicago
Max 26 Years
20
15
10
5
3
2
C H Res.
Wea Bureau
Intensity --- Inches per Hour
Duration --- Minutes
0
1
2
3
4
5
6
7
5
10
15
20
25
30
45
60
80
100
120
150
180

Fig 3.

of high intensity in all storms or the short periods, as from five to thirty minutes.

The maximum, 20-year and 15-year frequency curves are dependent upon a very few storms, and therefore the curves for one station may be greatly influenced by the fact that one gage was in a storm center, whereas the other gage may have been at some distance from the storm center and therefore in a less intense precipitation. In fact, the gages are so far apart that severe storms frequently pass over one without affecting the other.

The periods of precipitation were selected from the Chestnut Hill charts in a manner to assure the inclusion of the maximum total precipitation for the time under consideration. The Weather Bureau records, however, give the quantity for each even five minutes during the downpour. This difference in treatment of the recorded precipitation might give slightly different results even if the original charts were identical.

Chestnut Hill Records for Thirty-eight Years, 1879–1916, Inclusive. — Frequency curves for the entire period covered by

TABLE 5. — Coördinates of Precipitation Curves of Various Frequencies, according to the Chestnut Hill Records, Thirty-Eight Years, 1879–1916, Inclusive.

Duration. (Min.)	Intensity in Inches per Hour.						
	Maximum 38 Years.	Frequency.					
		20 Years.	15 Years.	10 Years.	5 Years.	3 Years.	2 Years.
5	9.10	7.50	7.40	5.80	4.56	3.97	3.71
10	6.70	5.17	4.85	4.57	3.52	3.03	2.81
15	5.40	4.17	3.82	3.53	2.84	2.52	2.27
20	4.65	3.59	3.31	3.00	2.42	2.17	1.97
30	3.60	2.75	2.65	2.48	1.87	1.75	1.55
45	2.58	2.08	2.00	1.94	1.58	1.37	1.24
60	2.06	1.79	1.65	1.60	1.35	1.15	1.05
80	1.70	1.48	1.35	1.30	1.11	0.92	0.85
100	1.45	1.29	1.18	1.06	0.89	0.76	0.70
120	1.29	1.20	1.02	0.88	0.75	0.66	0.61
150	1.13	1.10	0.87	0.72	0.62	0.57	0.51
180	1.01	1.01	0.79	0.65	0.54	0.50	0.45

the Chestnut Hill records, 1879–1916, inclusive, have been prepared. These curves are shown in Figs. 4 and 5, and the coördinates of these curves are compiled in Table 5.

Mathematical curves have been drawn which coincide as nearly as practicable with the 20-year, 15-year and 10-year frequency curves. The equations of these curves together with their coördinates and those of the original frequency curves are given in Table 6, from which the two sets of curves can be compared.

TABLE 6. — Comparison of Mathematical Curves with Chestnut Hill Frequency Curves (1879–1916).

Duration. (Min.)	$i = \frac{21.0}{t^{0.6}}$.	20-Year Frequency Curve.	$i = \frac{20.4}{t^{0.61}}$.	15-Year Frequency Curve.	$i = \frac{125}{t+20}$.	10-Year Frequency Curve.
5	8.00	7.50	7.64	7.40	5.00	5.80
10	5.28	5.17	4.95	4.85	4.17	4.57
15	4.13	4.17	3.91	3.82	3.57	3.53
20	3.48	3.59	3.28	3.31	3.12	3.00
30	2.73	2.75	2.56	2.65	2.50	2.48
45	2.14	2.08	2.00	2.00	1.92	1.94
60	1.80	1.79	1.68	1.65	1.56	1.60
80	1.52	1.48	1.41	1.35	1.25	1.30
100	1.32	1.29	1.23	1.18	1.04	1.06
120	1.19	1.20	1.10	1.02	0.89	0.88
150	1.04	1.10	0.96	0.87	0.74	0.72
180	0.93	1.01	0.86	0.79	0.63	0.65

Thirty-Eight Year Frequency Curve. — The 38-year frequency curve, which is in fact the maximum intensity curve, is determined by the intensities of precipitation reached in the three storms shown in Table 7.

The storm of July 18, 1884, was of determining importance only for the 5-minute period. The intensity during this period was the greatest of which there is record at Chestnut Hill. The intensity for 10 minutes was lower than that of the 20-year curve and practically identical with that of the 15-year curve. It was not significant therefore in the establishment of the maximum curve. The intensity for the 15-minute period was lower than that of the 10-year mathematical curve.

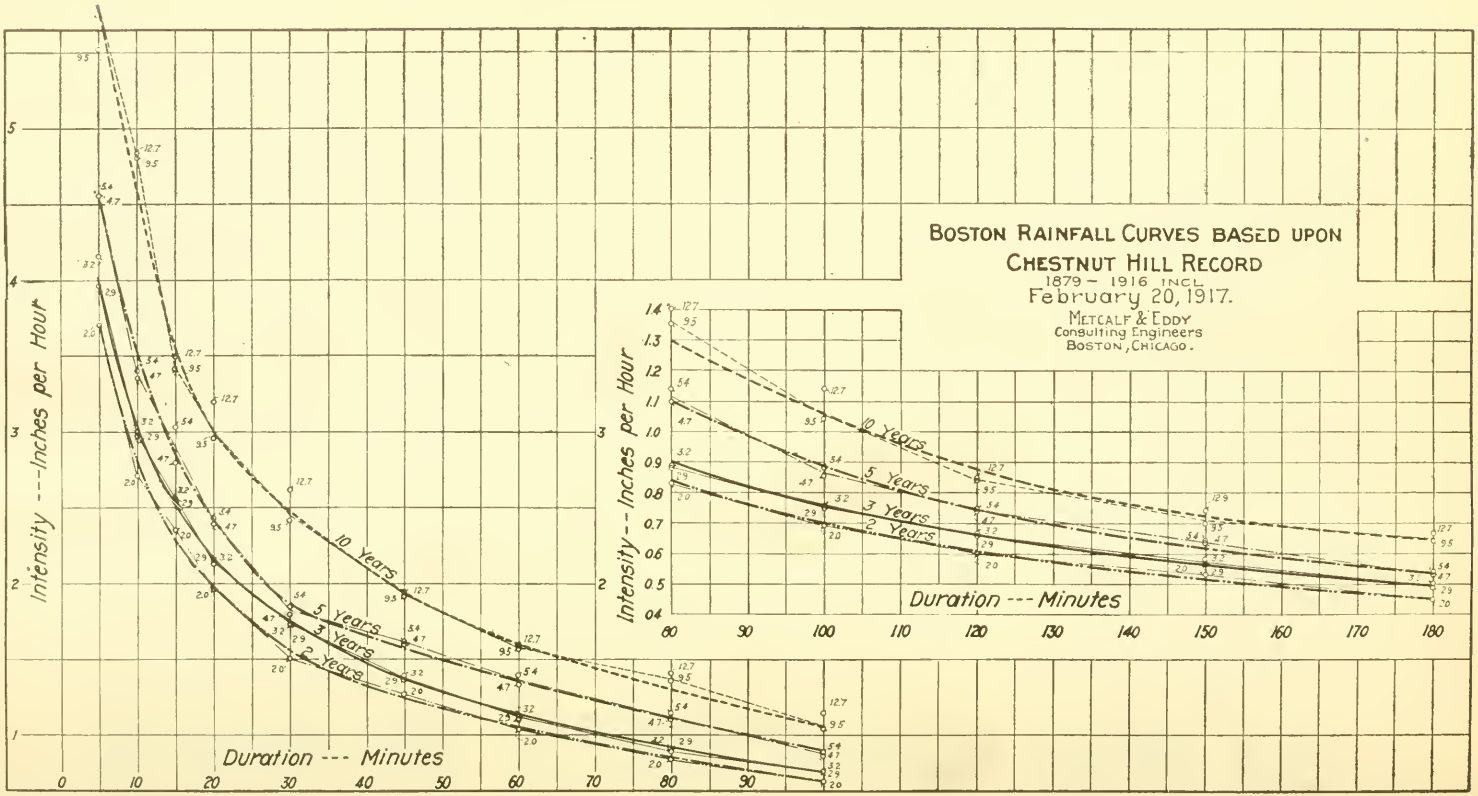

BOSTON RAINFALL CURVES BASED UPON
CHESTNUT HILL RECORD
1879 – 1916 INCL.
February 20, 1917.
METCALF & EDDY
Consulting Engineers
BOSTON, CHICAGO.
Intensity --- Inches per Hour
Duration --- Minutes
10 Years
5 Years
3 Years
2 Years
Intensity -- Inches per Hour
Duration --- Minutes
10 Years
5 Years
3 Years
2 Years

FIG. 4.

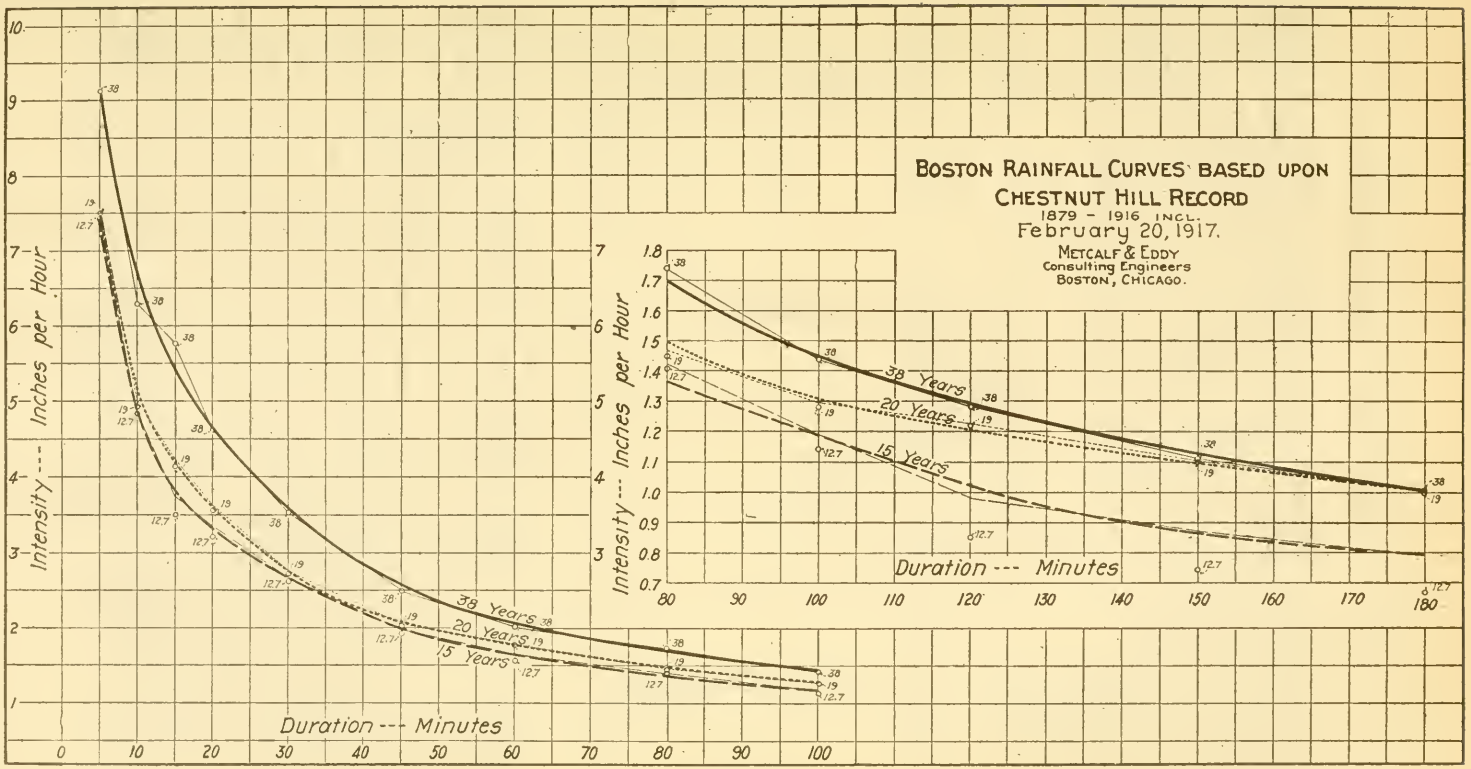

BOSTON RAINFALL CURVES BASED UPON
CHESTNUT HILL RECORD
1879 - 1916 INCL.
February 20, 1917.
METCALF & EDDY
Consulting Engineers
BOSTON, CHICAGO.
Intensity --- Inches per Hour
Duration --- Minutes
38 Years
20 Years
15 Years

FIG. 5.

The storm of August 22, 1899, appears to have been the most severe, from the point of view of city drainage problems, of any storm covered by the records. The intensities of this storm govern the maximum curve, for periods of from 10 to 80 minutes.

The storm of June 30 to July 3, 1915, had intensities for periods of from 100 to 180 minutes, which were of controlling importance. The intensities for shorter periods were not significant.

TABLE 7. — Rate of Precipitation of Extreme Storms, Inches per Hour.

Duration of Period.	July 18, 1884.	August 22, 1899.	June 30 — July 3, 1915.
5	9.12	7.42	2.37
10	4.93	6.30	2.09
15	3.41	5.77	1.90
20	...	4.62	1.81
30	...	3.53	1.74
45	...	2.50	1.62
60	...	2.02	1.57
80	...	1.74	1.45
100	...	...	1.43
120	...	...	1.28
150	..	...	1.11
180	...	...	1.01

From the foregoing discussion it will be seen that each of the three severe storms determined the location of a portion of the maximum intensity curve, but that no two storms supported the same part of the curve. It is clear, therefore, that any sewer designed on the basis of this curve would be utilized to its capacity only once in thirty-eight years and by that storm which furnished the maximum precipitation for the period corresponding to the time of concentration of the particular sewer under consideration. Furthermore, the sewer would not be called upon to provide for the maximum run-off until its drainage area should have been developed to the extent assumed for the end of the period for which the sewer is designed, nor under climatic or other conditions unfavorable to a maximum rate of run-off. To build sewers of capacity sufficient to accommodate the run-off from

TABLE 8. — Rates of Precipitation of Storms which Exceeded the Curve, $i=\frac{21.0}{t^{0.6}}$ (approx. 20-Year Frequency Curve), from 1879 to 1916.

(Inches per Hour.)

Duration of Period.	July 18, 1884.	August 22, 1899.	June 30, 1915.	July 20, 1880.
5	9.12	7.42	2.37	5.52
10	4.93	6.30	2.09	4.83
15	3.41	5.77	1.90	4.14
20	...	4.62	1.81	3.56
30	...	3.53	1.74	2.72
45	...	2.50	1.62	1.94
60	...	2.02	1.57	1.50
80	...	1.74	1.45	1.23
100	...	...	1.43	1.04
120	...	...	1.28	0.83
150	...	...	1.11	...
180	...	...	1.01	...

TABLE 9. — Rates of Precipitation of Storms which Exceeded the Curve, $i=\frac{20.4}{t^{0.61}}$ (approx. 15-Year Frequency Curve), from 1879 to 1916.

(Inches per Hour.)

Duration of Period.	July 18, 1884.	August 22, 1899.	June 30, 1915.	July 20, 1880.	August 25, 1901.	August 21, 1888.	September 25, 1911.
5	9.12	7.42	2.37	5.52	4.56	2.80	4.24
10	4.93	6.30	2.09	4.83	3.54	2.54	3.40
15	3.41	5.77	1.90	4.14	3.42	2.55	3.03
20	...	4.62	1.81	3.56	2.96	2.39	2.79
30	...	3.53	1.74	2.72	2.30	1.96	2.62
45	...	2.50	1.62	1.94	2.03	1.72	1.92
60	...	2.02	1.57	1.50	1.78	1.58	...
80	...	1.74	1.45	1.23	1.41	1.36	...
100	...	...	1.43	1.04	...	1.28	...
120	...	...	1.28	0.83	...	1.22	...
150	...	...	1.11	...	...	1.10	...
180	...	...	1.01	...	...	1.00	...

such storms under conditions favorable to maximum run-off and of the ultimate development would involve heavy expense justifiable only under very unusual circumstances. In fact, storms such as these may well be classed as acts of Providence, for which a city cannot reasonably be expected to provide.

Twenty-Year Frequency Curve. — The 20-year frequency curve may be represented approximately by the equation $i = \frac{21.0}{t^{0.6}}$. This form of equation applies equally well to both short and long periods of precipitation. It is not quite as easy of application as some other types of formulas, because it requires the use of logarithms. The intensities of precipitation for the several periods of time indicated by this curve are given in Table 6.

The rates of precipitation of three storms which exceeded this curve, and of a fourth storm which was practically coincident with it, for a short period of time, are given in Table 8. The intensities enclosed within the rectangular areas are those which exceeded the intensities indicated by the mathematical curve. It will be seen that there were but two storms during which the intensities indicated by the mathematical curve were exceeded for the same time lengths, and it may be added that the storm of July 20, 1880, while exceeding this curve, did not exceed the curve as originally plotted from the observed intensities. In other words, the mathematical 20-year frequency curve does not appear to have been materially exceeded but once, for a substantial time length, by the storms recorded at Chestnut Hill. It appears, therefore, that a city would seldom be justified in basing the design of sewers and drains upon this curve, for the reasons given in connection with the maximum 38-year frequency curve.

Fifteen-Fear Frequency Curve. — The 15-year frequency curve may be represented approximately by the equation $i = \frac{20.4}{t^{0.61}}$. The intensities of precipitation indicated by this curve for the several time lengths are given in Table 6.

Records of storms which have had intensities in excess of those indicated by this curve are compiled in Table 9. The

intensities enclosed within the rectangular areas are those which exceeded the intensities indicated by the mathematical curve. It will be seen that there were 7 such storms in all. That of September 25, 1911, is of small moment; in fact, its intensity does not exceed the frequency curve as plotted from the recorded data. Practically no portion of the curve was exceeded more than twice in 38 years.

While it may be argued with some justice that this curve indicates intensities higher than those which a city is normally justified in providing for, it will be shown below that the 10-year frequency curve, while exceeded much more frequently, does not indicate intensities sufficiently low to result in the use of materially smaller sizes of sewers. In many cases the differences between the 15-year and 10-year frequency curves would be too small to result in any difference in the size of sewer. It therefore would seem reasonable to adopt for the design of storm-water sewers by the rational method the 15-year frequency curve indicated by the equation, $i = \frac{20.4}{t^{0.61}}$, subject, of course, to any special needs or conditions of the drainage district under consideration.

Ten-Year Frequency Curve. — An equation for the 10-year frequency curve has been developed, differing in form from those computed for the 20-year and 15-year frequency curves. The equation of the 10-year frequency curve is $i = \frac{125}{t+20}$. This form of equation does not apply as well as the exponential form to the very short and very long periods. It is, however, somewhat easier to apply, as it does not require the use of logarithms. The intensities of precipitation indicated by this equation are compiled in Table 6. The records of storms which have exceeded the 10-year mathematical frequency curve have been compiled in Table 10. There have been 12 such storms, although 5 of them exceeded the intensities indicated by the curve for only a single period of time. The storms of August 22, 1899; June 30, 1915; July 20, 1880; August 25, 1901, and August 21, 1888, exceeded the intensities indicated by the curve for substantial lengths of time, and 4 of these 5 storms overlapped. This indi-

cates that a sewer having a concentration period of 60 minutes would have been overcharged by all these storms were its drainage area developed to the extent assumed in the design and were conditions favorable to maximum run-off. It is also important to note that even in those storms in which the mathematical curve intensities were exceeded for only a single period, these periods of excessive precipitation were sufficiently long to have an important effect upon the discharge of many sewers.

The number of times the capacities of sewers designed to serve the storms represented by the 10-year mathematical frequency curve have been exceeded is so large that a city might not be able to justify a policy of basing the design of its sewers upon a curve of so great a frequency.

TABLE 10. — RATES OF PRECIPITATION OF STORMS WHICH EXCEEDED THE CURVE, $i = \frac{125}{t+20}$ (APPROX. 10-YEAR FREQUENCY CURVE), FROM 1879 TO 1916, INCLUSIVE. (Inches per Hour.)

Duration of Period.	July 18, 1884.	August 22, 1899.	June 30, 1915.	August 6, 1893.	July 20, 1880.	August 25, 1901.	August 21, 1888.	July 21, 1894.	September 25, 1911.	September 20, 1899.	August 12, 1892.	August 16, 1879.
5	9.12	7.42	2.37	7.45	5.52	4.56	2.80	4.11	4.24	2.27	3.76	2.96
10	4.93	6.30	2.09	4.74	4.83	3.54	2.54	3.90	3.40	1.89	2.97	2.55
15	3.41	5.77	1.90	3.36	4.14	3.42	2.55	3.50	3.03	1.81	2.79	1.97
20	..	4.62	1.81	2.61	3.56	2.96	2.39	3.20	2.79	1.64	2.43	1.65
30	...	3.53	1.74	2.14	2.72	2.30	1.96	...	2.62	1.39	2.42	1.23
45	...	2.50	1.62	...	1.94	2.03	1.72	...	1.92	1.29	1.85	0.95
60	...	2.02	1.57	..	1.50	1.78	1.58	...	...	1.21	1.57	0.88
80	..	1.74	1.45	...	1.23	1.41	1.36	...	...	1.14	1.23	0.88
100	...	...	1.43	...	1.04	...	1.28	...	...	1.14	1.02	0.88
120	...	...	1.28	...	0.83	...	1.22	...	...	...	...	0.84
150	...	...	1.11	...	...	.	1.10	...	...	...	...	0.74
180	...	...	1.01	...	...	...	1.00	...	...	...	...	0.67

MEMOIRS OF DECEASED MEMBERS.

EDMUND GROVER.*

Edmund Grover, son of the late David F. and Ann M. (Lewis) Grover, died at his home in East Walpole, on October 19, 1919, after an illness of several months.

He was born in East Walpole, April 7, 1855, and was educated in the public schools of Walpole and the Massachusetts Institute of Technology, from which he graduated in the class of 1877 with the degree of S.B.

For two years following graduation he was associated with his father in paper making in New Boston, N. H.

After this period he went West and was connected for a number of years with various railroad companies in their civil engineering and construction departments, including the Chicago, Burlington & Quincy Railroad; Chicago and Grand Trunk; Indiana; Atchison, Topeka & Sante Fé; Colorado, and several smaller lines.

In 1891 he returned East, and for a time was in the office of Olmsted, Olmsted and Eliot, landscape architects. He developed considerable taste for the esthetic side of this branch of engineering and opened an office in East Walpole, where he practiced civil engineering and landscape gardening during the rest of his active life.

He was a member of the Massachusetts Forestry Association and the state and local granges.

As a citizen he was deeply interested in the public schools, and for six years was a member of the school committee, and with his intelligent and progressive ideas he advanced the cause of education.

He was a lover of the best in literature, and a deep thinker on all the important subjects of the times, particularly those pertaining to national affairs.

* Memoir prepared by Richard A. Hale and Arthur L. Plimpton.

He was married in 1883 to Isabelle Jondro, of Milford, N. H. They had three children, E. Stanley, who is a civil engineer with the American Steel and Wire Company of Worcester, Mass.; Arnold F., director of manual training in the Walpole public schools, and Shirley I., wife of Frederick V. Bell, of East Walpole.

These three children with his widow survive him.

IRVING SPARROW WOOD.*

Irving Sparrow Wood, son of Charles P. and Sarah S. (Robinson) Wood, was born November 27, 1857, in the city of Providence, and died in the same house in which he was born, October 20, 1919.

He came of early New England stock and could trace his ancestry back to the days of Governor Bradford of Massachusetts.

He was married to Margaret E. Reed, October 14, 1903.

Mr. Wood was educated in the public schools and in Mowry & Goff's English and Classical School, from which he graduated in June, 1877.

He began his professional career when he entered the City Engineer's Office of the city of Providence in the fall of 1877. Most of his time was spent in connection with the Providence Water Works and on May 1, 1899, he was appointed assistant engineer in charge of the Water Department, a position which he held until his death.

He joined the American Society of Civil Engineers as junior, March 5, 1890, became an associate, March 7, 1900, and a member, March 6, 1906. He was also a member of the Boston Society of Civil Engineers, the New England Water Works Association and the Providence Engineering Society.

Mr. Wood was unassuming in manners, conscientious and faithful in the discharge of all duties assigned to him, and a loyal and agreeable associate and friend.

* Memoir prepared by William D. Bullock and James A. McKenna.

Vol. VII MARCH, 1920 No. 3

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PROCEEDINGS

PAPER IN THIS NUMBER.

"Small Sewage Pumping Stations." Eugene F. Leger.

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Contributors are hereby notified that proof will not be submitted to them for examination unless requested before the 10th of the month preceding the month of publication.

MINUTES OF MEETINGS.

BOSTON, February 18, 1920. — A regular meeting of the Boston Society of Civil Engineers was held this evening at Chipman Hall, Tremont Temple, and was called to order by the President, Mr. Leonard Metcalf, at 7.50 o'clock.

There were 105 members and visitors present.

The record of the last meeting was read and approved.

The Secretary reported, for the Board of Government, the election of Mr. Herman Scott Price to membership in the grade of member.

The committee, Messrs. H. B. Wood, E. S. Smilie and E. P. Adams, appointed to prepare a memoir of Edward A. Buss, submitted its report and by vote it was accepted and ordered printed in the JOURNAL of the Society.

The deaths of the following members were announced: Frank L. Fuller, who died January 30, 1920; and R. Winthrop Pratt, who died February 2, 1920. By vote, the President was

requested to appoint committees to prepare memoirs. The members of the committees selected by the President are: On memoir of Mr. Fuller, John C. Chase; on memoir of Mr. Pratt, Morris Knowles and George W. Fuller.

On motion of Mr. Rogers, the following vote, passed at the last meeting, was passed a second time, as required by the By-Laws, by a unanimous vote:

"*Voted:* That the entire income of the Permanent Fund for the current year be appropriated and placed at the disposal of the Board of Government for use in payment of the expenses of the Society so far as in their judgment it is deemed advisable."

The President then submitted the report of the Committee on Compensation of Engineers made to the Board of Government, which had been printed and sent to the membership of the Society with the notice of this meeting; and called on Col. Charles R. Gow, the chairman of the committee, for any explanations he cared to make. Colonel Gow responded briefly with an account of the work of the committee and the reasons for its conclusions. As the time for taking up the literary exercises of the meeting, as provided in the By-Laws, has nearly arrived, on motion of Mr. Morphy it was voted that when the meeting adjourned it be to next Wednesday evening, February 25, at eight o'clock, and that the adjourned meeting be devoted to discussion and action on the report of the Committee on Compensation of Engineers.

The President then presented Mr. Edmund M. Blake, a member of the Society, who gave a most interesting account of the Douglas Fir Industry on the Pacific Coast and Its Preservative Treatment by the Perforating Process. The address was very fully illustrated with lantern slides, and a complete working model of the drum of the perforating machine was shown.

Mr. Blake was followed by Mr. Chester J. Hogue, a former member of the Society, who spoke particularly of Douglas fir for structural uses.

Mr. Lowry Smith, assistant engineer of maintenance, Northern Pacific Railroad, was then introduced and spoke briefly of methods of creosoting Douglas fir and other timber.

Colonel Gow, in offering a motion for a vote of thanks to

the speakers of the evening, expressed his regrets that Mr. Blake was automatically debarred from the vote because he possessed the greater honor of being a member of the Society. The vote extending the thanks of the Society to Mr. Hogue and Mr. Smith for their entertaining addresses was then unanimously adopted.

The meeting then adjourned to next Wednesday evening, at eight o'clock.

S. E. Tinkham, *Secretary.*

Boston, February 25, 1920.—The adjournment of the last regular meeting of the Society was called to order this evening at Chipman Hall, Tremont Temple, at 8.05 o'clock, by the President, Leonard Metcalf.

There were present 78 members.

The President stated the last meeting was adjourned to this date for the discussion of the report of the Committee on Compensation of Engineers, and he asked the Secretary to open the discussion by reading communications which had been received from members of the Society.

The Secretary then read letters from X. Henry Goodnough, Edward Wright and Kenneth P. Armstrong.

The discussion was continued by Lewis E. Moore, Frank B. Walker, John E. L. Monaghan, Harrison P. Eddy, Charles R. Gow, Frank P. Hodgdon, Luis G. Morphy, Charles M. Spofford, Edgar S. Dorr, Edward P. Adams and others.

Mr. Eddy moved: That the report of the Committee on Compensation of Engineers be referred back to the committee with the request that further consideration be given to the schedule of salaries to be recommended, to the wording of the report, and to such other matters as the committee may deem advisable.

Mr. Gow felt that it would be better to refer the report to a new committee on which there should be adequate representation of publicly employed engineers, and that personally it would not be possible for him to do any work on the committee at present for the reason that he would leave early next week on

a trip, to be absent some six weeks or more. He therefore moved an amendment to the motion to the effect that the report be referred to a new committee.

On a vote being taken on Mr. Gow's amendment, it was lost (15 in favor and 25 against).

Mr. Eddy's original motion was then adopted by a unanimous vote.

Mr. Eddy then offered the following motion, and moved its adoption:

"That this meeting commend to the favorable consideration of the Committee on Compensation of Engineers the suggestions that:

"(*a*) Government, state and municipal engineering service should command compensation measurably greater than the equivalent service rendered to other parties.

"(*b*) There should be a substantial vertical rise from the upper limit of one grade to the lower limit of the next higher grade.

"(*c*) An effort should be made to formulate and secure governmental, state and municipal adoption of a plan for the automatic increase in compensation, within each grade of service and between the limits fixed, said increase to be dependent upon and in a measure commensurate with the length of the term of service.

"(*d*) The schedule of salaries advocated by Engineering Council is reasonable, just to employer and employee, and should be endorsed by this Society, and such endorsement I believe requires certain formalities.

"(*e*) In cases where the public authorities are unwilling to grant increases in compensation sufficient to provide salaries equal to the schedule of Engineering Council, this Society should approve an increase equivalent to about 40 per cent. in all grades of service — with the distinct understanding that such increase is to constitute simply a first step, and that further increases should be forthcoming from year to year as rapidly as possible until the schedule of Engineering Council shall have been put into effect."

On a vote being taken, the motion was adopted.

Mr. Morphy said he would like to obtain the sense of the meeting in regard to the approval of Senate Bill No. 196, and on a call for the provisions of the bill the President read the bill in full.

Mr. Eddy moved: That it is the sense of this meeting that this bill should be supported and that the Board of Government should provide that the Society be represented at any public hearing upon the bill. Mr. J. L. Howard moved, as an amendment to the motion, that it is the sense of the meeting that the Board of Government be authorized to support the schedule of Engineering Council in place of that recommendation by the bill. On a vote being taken, the amendment was adopted.

Mr. Eddy's motion as amended was then adopted.

By a unanimous vote, the thanks of the Society were tendered to the Committee on Compensation, for its work.

Adjourned.

S. E. TINKHAM, *Secretary.*

BOSTON, February 11, 1920. — The Sanitary Section of the Boston Society of Civil Engineers held a special meeting this evening in the Society Library, Tremont Temple. The meeting was called to order by the chairman, Edgar S. Dorr, at 7.45 P.M.

The record of the December meeting was approved as printed in the Society JOURNAL.

The chairman introduced Mr. Eugene F. Leger, of the Power Equipment Company, who gave a very interesting talk on "Small Sewage Pumping Stations." Mr. Leger related the difficulties that had been encountered in the pumping of sewage, and described in detail the latest practice in pump design.

On motion of Mr. Marston, a rising vote of thanks was given to the speaker, for his courtesy in presenting this paper.

Adjourned at 9.30 P.M. Members present, 32.

JOHN P. WENTWORTH, *Clerk.*

APPLICATIONS FOR MEMBERSHIP.

[March 17, 1920.]

THE By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

BADGER, ALBERT WILLIAM, Hyde Park, Mass. (Age 39, b. Roxbury, Mass.) Educated in public schools. With William O. Badger on general survey work; assistant engineer, town of Hyde Park, 1905 to 1912; assistant engineer, City of Boston, in sewer and paving divisions, Public Works Department, from 1912 to date. Refers to B. F. Bates, E. S. Dorr, C. S. Drake, G. W. Hamilton, J. E. L. Monaghan and E. F. Murphy.

COLE, HAROLD STEPHEN, Framingham, Mass. (Age 23, b. Ashland, Mass.) Educated in the public schools and International Correspondence School. Experience, four months in drafting room of International Engineering Works, Framingham, Mass.; about three years draftsman with Guilee Engineering Co., Framingham; about one year draftsman with Mead-Morrison Co., East Boston. With the 6th Regiment during the war, discharged in April, 1919. Returned to Mead-Morrison Co., and remained till August, 1919; with French & Hubbard, civil engineers, Boston, till November, 1919, and since then with U. S. Color & Chemical Co., Ashland, Mass. Refers to F. H. Clark, C. E. Haberstroh, W. W. Locke and J. F. Wilbur.

COLEMAN, GEORGE STEPHEN, Boston, Mass. (Age 35, b. South Framingham, Mass.) Student at Boston Mechanic Arts High School, 1900 to 1904, and at Massachusetts Institute of Technology, 1904 to 1907; rodman, Charles River Basin Commission, July, 1907, to June, 1910, and Metropolitan Park Commission, June, 1910, to July, 1911; transitman, Public Works De-

partment, Boston, July, 1911, to 1913, and senior transitman, same department, till 1915; assistant engineer, same department, to present. Refers to D. A. Ambrose, J. E. Carty, E. S. Dorr, J. N. Ferguson and J. E. L. Monaghan.

Connor, John Edward, Boston, Mass. (Age 53, b. Maplewood, Mass.) Educated at Maplewood Grammar School and Boston English High School; took course in Boston Evening Drawing School and courses in mathematics under private tutor. Inspector in Sewer Service, City of Boston, 1900 to 1904; draftsman, City of Boston, 1904 to 1910; designer and draftsman, City of Boston, 1910 to 1918; designer, personal office, Q. M. C., U. S. Army, 1918 to 1919, and at present time designer and draftsman, City of Boston. Refers to T. F. Bowers, E. S. Dorr, C. S. Drake, D. P. Kelley, R. J. McNulty and J. E. L. Monaghan.

Ellis, Richard Henry, North Adams, Mass. (Age 27, b. Lawrence, Mass.) Graduate Dartmouth College, degree of S.B. in 1916; while in college was enrolled as member of Thayer School of Civil Engineering. In 1916 was draughtsman with George Adams, architect; and since September, 1916, engineer and superintendent of Board of Public Works of North Andover, Mass., in charge of maintenance and construction of water works and of the sewer system. Refers to J. R. Baldwin, H. K. Barrows, H. W. Clark, R. A. Hale and A. D. Marble.

Fraser, Charles Edward Kingston, Oyster Bay, N. Y. (Age 42, b. England.) Graduate of International Correspondence School, 1910. From 1901 to 1907 engaged in landscape engineering; from 1907 to April, 1908, inspector for Engineer Corps, Pennsylvania Tunnels, New York to Long Island City; from April, 1908, to July, 1916, engaged in landscape engineering and construction; from July, 1916, to April, 1917, engineer of construction, All Saints Church, Peterboro, N. H.; from April, 1917, to February, 1919, commissioned officer, Corps of Engineers, U. S. Army, discharged as captain, commanded reconstruction of Aprémont, St. Mihiel Road, Flirey Essey Road, and assisted on construction of Le Réné Forest and Mandras Road. Battalion citation for efficiency. Has executed plans for various architectural firms of Boston and New York. At present engaged in business for himself as civil and landscape engineer. Elected an associate of the Society, December 20, 1916, and now desires to be transferred to grade of member. Refers to G. P. Connolly, J. F. A. Giblin, A. L. Shaw, G. F. Webb and A. D. Weston.

Haskell, George Freeman, Boston, Mass. (Age 46, b. Boston, Mass.) Educated Boston English High School, Class 1892. From 1893 to 1895, employed as rodman and transitman by H. T. Whitman, C.E.; from 1895 to 1911 with surveying division, City of Boston, as transitman in charge of surveying party, and since February, 1911, has been in designing room of sewer service, City of Boston. At present, assistant engineer, Boston Public Works Department, Sewer Service. Refers to E. S. Dorr, Channing Howard, D. P. Kelley, R. J. McNulty, J. E. L. Monaghan and F. O. Whitney.

Hoar, William V. P., Dorchester, Mass. (Age 37, b. Boston, Mass.) Graduate Mechanic Arts High School, Boston, in 1901, and completed course

in civil engineering in International Correspondence School about 1908. With Aspinwall & Lincoln as rodman and transitman, 1901 to 1903; with Metropolitan Park Commission in same position till 1907; with City of Boston, sewer service, in same position till 1910 and since 1910 assistant engineer in Boston Sewer Service. Refers to E. S. Dorr, C. S. Drake, D. P. Kelley, F. A. Lovejoy and J. E. L. Monaghan.

Holmes, Frank Oscar, Boston, Mass. (Age 44, b. Newton, Mass.) With Aspinwall & Lincoln, Boston, October, 1895; Boston Transit Commission, January, 1896, to April, 1898; U. S. Volunteer Signal Corps (military service); Boston Park Dept., August, 1899, to January, 1900; Boston Transit Commission, June, 1900, to February, 1902; White Mountain Paper Company, June, 1902, to March, 1903; Mass. Highway Commission, April, 1903, to November, 1903; Boston Sewer Division, November, 1903, to May, 1906; Quartermaster's Dept., West Point (civil), July, 1906, to November, 1907; Paving Dept., Highway Division, Boston, August, 1908, to April, 1913; Permit Dept., Highway Division, Boston, April, 1913, to January, 1916; Boston Sewer Service, July, 1916, to May, 1918; Boston Highway Service, May, 1918, to March, 1919; Boston Sewer Service, March, 1919, to present. Now assistant engineer, Sewer Service, Public Works Dept., Boston. Refers to Joshua Atwood, T. F. Bowers, H. A. Carson, G. C. Emerson and C. R. Gow.

Lynch, Daniel Joseph, Dorchester, Mass. (Age 47, b. Charlestown, Mass.) Educated in Dorchester High School and International Correspondence School. Has had twenty-five years' experience on engineering work. Now assistant engineer, Public Works Dept., City of Boston. Refers to J. E. Carty, E. S. Dorr, C. S. Drake, J. E. L. Monaghan and E. F. Murphy.

Maloy, Walter A., Boston, Mass. (Age 39, b. Boston, Mass.) Graduated from Boston English High School. Attended Boston College two years, in 1909 took course in plane surveying and railroad engineering at Harvard College Engineering Camp, and, in 1911, took course in Mechanics of Materials at Franklin Union; from 1909 to 1912, with Boston Elevated Railway on Cambridge subway and Malden extension as instrumentman and chief of party; 1912 to 1918, with Boston Sewer Dept. as draftsman and designer; in 1918 was with the Cerro de Pasco Copper Corporation in Peru on geological and underground surveys; since 1919 and at present with Boston Sewer Dept. as draftsman and designer. Refers to T. F. Bowers, E. S. Dorr, C. S. Drake, D. P. Kelley, R. J. McNulty and J. E. L. Monaghan.

Moulton, Joseph Wendell, Augusta, Me. (Age 26, b. Barnet, Vt.) Graduated in civil engineering at University of Maine in 1917. Entered U. S. Geological Survey as junior engineer, July, 1916; was assigned to duty in New York State and transferred to Boston, August, 1918; entered U. S. Army in September, 1918; discharged December, 1918; returned to the Geological Survey, Washington office, December, 1918; reassigned to Boston office in February, 1919; transferred to Albany office, March, 1919; promoted to assistant engineer, July, 1919; returned to Boston office in August, 1919, and assigned to Augusta, Me., to coöperate with Maine Water Power Commission in the collection of stream flow data, in which work he is now engaged.

Refers to H. S. Boardman, G. C. Danforth, C. H. Pierce and M. R. Stackpole.

Murphy, Daniel A., Dorchester, Mass. (Age 37, b. Boston, Mass.) Graduate Boston Mechanic Arts High School in 1905, attended structural course, Lowell Institute, in 1907, and Franklin Union, 1914–15. With Purdy & Henderson, civil engineers, on structural steel work, 1904–05; City of Boston, Sewer Service, as rodman, 1905–06; Boston School House Commission as rodman, transitman and assistant engineer, from 1907 to date. Now assistant engineer with School House Commission. Refers to J. J. Casey, E. S. Dorr, C. S. Drake, F. A. Lovejoy, R. J. McNulty and J. E. L. Monaghan.

Norris, Clarence George, Hyde Park, Mass. (Age 53, b. Chelsea, Mass.) Graduate in civil engineering, Mass. Institute of Technology, Class of 1890. Assistant engineer, Louisville Div. P. C. C. & St. L. Ry., 1890 to 1896; 1896 to 1900, inspector and assistant engineer, Hyde Park Sewer Commission; 1900 to 1903, superintendent of streets, Hyde Park; 1904 to 1912, engineer for Town of Hyde Park, outside of sewers; 1904 to 1912, town engineer of Hyde Park, and from 1912 to present time, assistant engineer in sewer service and paving division, City of Boston. Refers to E. S. Dorr, C. R. Gow, E. A. W. Hammatt, F. A. McInnes, J. E. L. Monaghan, E. F. Murphy and C. W. Sherman.

Parker, Edwin S., Brookline, Mass. (Age 32, b. Minneapolis, Minn.) A student in civil engineering for two years at the University of California, but was obliged to leave before graduation on account of sickness. In addition to summer work while at college, his experience has been in office of Cram & Ferguson, in 1916; with H. F. Kellogg, architect, from May, 1917, to July, 1918, latter part of time in charge of office and engineering work; from December, 1918, to present time, with James E. McLaughlin, architect, as engineer on structural work. Refers to J. J. Casey, J. E. Hanlon, Linton Hart and H. L. White.

Patterson, Herbert Lamb, Boston, Mass. (Age 46, b. St. Stephens, N. B.) Educated in public schools and course in structures in Y. M. C. A. in 1902. Rodman, city surveyor's office, 1893–97; transitman, 1897–1907; assistant to engineer, School House Commission, 1907–10, and since 1910 engineer in charge, School House Commission. Refers to F. B. Bates, C. S. Drake, F. A. Lovejoy, F. M. Miner, J. E. L. Monaghan and F. O. Whitney.

Pike, Waldo Francis, Newton Highlands, Mass. (Age 27, b. Cambridge, Mass.) Graduate Mass. Institute of Technology, 1915, civil engineering course. From 1915 to March, 1916, with the New England Structural Company; March, 1916, to June, 1916, assistant bridge inspector, B. & M. R.R.; June, 1916, to October, 1916, structural draftsman, B. & M. R.R.; and from October, 1916, to present time with Fay, Spofford & Thorndike. For eleven months, 1917 and 1918, loaned to Turners Falls Power and Electric Company on design of power house; one month in 1919, loaned to Parker, Thomas & Rice, on design of steel building, and four months to C. T. Main on general building work. Elected a junior, March 21, 1917, and now desires to be transferred to grade of member. Refers to C. R. Berry, B. A. Bowman, B. A. Rich, H. F. Sawtelle, H. C. Thomas and S. H. Thorndike.

PITMAN, MARK EDGAR, Boston, Mass. (Age 37, b. East Boston, Mass.) Graduate, East Boston High School, 1899. Employed by Metropolitan Sewerage Commission as rodman and transitman, 1899 to 1903; City of Boston, sewer service as transitman and assistant engineer on surveys, design and construction sewers, from 1903 to present time. Refers to T. F. Bowers, E. S. Dorr, G. W. Hamilton, J. E. L. Monaghan and E. F. Murphy.

REYNOLDS, KENNETH CASS, Somerville, Mass. (Age 23, b. Somerville Mass.) Graduate of Tufts College in 1919, with B.S. degree in civil engineering. Has been with Fay, Spofford & Thorndike on field and office work since September, 1919. Refers to C. R. Berry, R. W. Horne, E. H. Rockwell, H. F. Sawtelle, R. C. Smith and W. D. Trask.

SHERMAN, HENRY ARTHUR, Boston, Mass. (Age 46, b. West Lebanon, N. H.) Graduate Mass. Institute of Technology in 1897, mining engineering course. With Public Works Dept., City of Boston, 1897 to 1920, and at present assistant engineer, Sewer Service, City of Boston. Refers to T. F. Bowers, E. S. Dorr, C. S. Drake, G. W. Hamilton, F. A. Lovejoy and J. E. L. Monaghan.

WALKER, EDWARD LLOYD, Framingham, Mass. (Age 45, b. Milford, Mass.) Graduate, Worcester Polytechnic Institute, 1897, in civil engineering. From 1897 to 1900, rodman and instrumentman with Metropolitan Water Board; 1900–02, draftsman, Pennsylvania & Northwestern R. R.; 1902–03, draftsman Jersey City Water Supply Co.; 1903–04, resident engineer with Hazen & Fuller, on construction of additional water supply for Meadville, Penn.; 1904–05, engineer in charge of party with National Board of Fire Underwriters; 1905–10, engineer in charge of designing and drafting division, New York City Aqueduct Commission; 1910–13, supervising engineer with Dept. of Water Supply, Gas and Electricity, New York City; 1914–15, division engineer, Water Supply Commission of Penn., and 1915 to date, assistant engineer with Fay, Spofford & Thorndike, principally on water works, valuation and design, except part of 1917–18, when he was with Monks & Johnson in connection with new destroyer plant at Squantum, Mass. Refers to A. O. Doane, F. H. Fay, A. D. Flinn, R. W. Horne, J. S. Lamson, J. W. Smith.

YOUNG, ERNEST MURDOCK, Boston, Mass. (Age 40, b. Cambridge, Mass.) Rodman, City of Boston, Sewer Service, from 1896 to 1903; transitman from 1903 to 1906; May and June, 1906, transitman on surveys, Mass. Highway Commission, and from July, 1906, to date, junior engineer, Boston Sewer Service, on sewer design, layout of separate system of drainage areas in charge of construction work, etc. Now assistant engineer in sewer service of City of Boston. Refers to E. S. Dorr, G. W. Hamilton, F. A. Lovejoy, J. E. L. Monaghan, E. F. Murphy and H. A. Wilson.

LIST OF MEMBERS.

ADDITIONS.

BUDD, GEORGE, Jr.....28 Chester St., Lowell, Mass.
PRICE, HERMAN S.,
U. S. Geological Survey, Custom House Bldg., Boston, Mass.

CHANGES OF ADDRESS.

BARNES, ROWLAND H.....Nat'l Bank Bldg., Waltham, Mass.
BARNES, WILLIAM T.....The Spring Brook Water Supply Co., 30 North Franklin St., Wilkesbarre, Pa.
BARNEY, HAROLD B.....18 Spooner Road, Chestnut Hill 67, Mass.
BOWERS, GEORGE W.....359 Westford St., Lowell, Mass.
BROWN, C. LEONARD, The Argyle Apts., 17th, M and Park Road, Washington, D. C.
DE LA HAYE, ELIAS F., Jr.....50 Perrins Steet, Roxbury, Mass.
FULLER, W. B.....1316 Washington Bldg., Los Angeles, Calif.
GREEN, HOWARD W.....383 So. Main St., Woonsocket, R. I.
GUINEY, J. A.....22 Bennett St., Brighton, Mass.
HANNAH, THOMAS E.....70 Congress St., Fitchburg, Mass.
JOHNSON, FRANK W., Care Raymond Concrete Pile Co., 140 Cedar St., New York, N. Y.
JOHNSON, GEORGE A.....150 Nassau St., New York, N. Y.
LOHMEYER, WILLIAM, Capt., U. S. A. Hospital No. 28, Ward 65, Fort Sheridan, Ill.
MCNULTY, R. J.....49 Rosseter St., Boston 21, Mass.
MORRILL, FRANK P.....Wise Rover, Mont.
PERKINS, CLARENCE A.....22 Wilson Ave., Malden, Mass.
REW, MORSE W.....301 Falls St., Niagara Falls, N. Y.
RICH, B. A.....Care Lockwood, Green & Co., 245 State St., Boston, Mass.
SAMPSON, GEORGE A.....83 Pembroke St., Newton, Mass.
SOCOLL, J. M.....Care Aberthaw Const'n Co., Box 868, Danville, Va.
STARR, JOHN A.....100 Savin Hill Ave., Dorchester, Mass.
WADE, CLIFFORD L.....Care A. B. Drake, William St., New Bedford, Mass.
WARREN, HENRY E.....37 Temple St., Boston, Mass.
WIGGIN, THOMAS H.....School Lane, Scarsdale, N. Y.

DEATHS.

CARR, JOSEPH L.....February 12, 1920
NORCROSS, ORLANDO W.....February 27, 1920
OLMSTEAD, JOHN C.....February 24, 1920

PERSONAL NOTE.

WILLIAM T. BARNES, M. Am. Soc. C. E., has withdrawn from the firm of Metcalf & Eddy, consulting engineers of Boston, to become chief engineer of the Spring Brook Water Supply Company which supplies Wilkesbarre, Pa., and vicinity.

Mr. Barnes was graduated from the Massachusetts Institute of Technology in 1893, and after a few years on railroad work

in Indiana and on water-works construction with Rice & Evans, entered the employ of Leonard Metcalf, with whom, and his successor, the firm of Metcalf & Eddy, he has been ever since. In 1913 Mr. Barnes was admitted as a partner, and he was for about seven years in charge of the Chicago office of the firm.

In his new position Mr. Barnes will have charge of the design and construction of new works and of the technical maintenance and operation of the existing works, furnishing water to a population in excess of 300 000, including besides Wilkesbarre the cities and towns of Pittston, Plymouth, Kingston and Nanticoke, and a number of other smaller communities.

LIBRARY NOTES.

Recent Additions to the Library.

U. S. Government Reports.

Boston Army Supply Base. Final Report of Fay, Spofford & Thorndike, Designing and Supervising Engineers. 2 vols. in manuscript and 5 vols. of blueprints.

Commercial Engineering. Report of a Conference on Business Training for Engineers. 1919.

Cotton Production and Distribution. Season 1918–19.

Mortality Statistics for 1918.

State Reports.

Massachusetts. State Department of Health. Annual Report for 1917.

Illinois. Consolidation of Local Governments in Chicago. 1919.

City and Town Reports.

Boston, Mass. Annual Report of Public Works Department for 1918.

Concord, Mass. Annual reports for 1919.

Danvers, Mass. Annual Report of Water Commissioners for 1919.

New York City. Development and Present Status of City Planning. 1914.

New York City. Establishment of Setbacks and Court Yards. 1917.

New York City. Report of Chief Engineer of Board of Estimate and Apportionment. 1917.

New York City. Final Report, Commission on Building Districts and Restrictions. 1916.

New York City. Building Zone Resolutions 1916 and amendments to July, 1919.

New York City. Height District Maps. Folio of 35 sheets. 1916.

New York City. Area District Maps. Folio of 35 sheets. 1916.

New York City. Use District Maps. Folio of 35 sheets. 1916.

(All of above reports relating to New York City are the gift of Mr. Thomas W. Clark, C.E., Brookline, Mass.)

New York City, The Transit Problems of. Discussion by Mr. D. F. Wilcox and others.

Northampton, Mass. Annual reports for 1918.

Rutland, Vt. Annual Report for 1919.

Miscellaneous.

American Society for Testing Materials. Vol. 19, Parts I and II. 1919.

Estimating Concrete Buildings, by Clayton W. Mayers. 1920. Gift of Aberthaw Construction Company.

Metropolitan Road and Rail Transit, by H. H. Gordon. Lecture before the Institute of Civil Engineers, London. 1919.

Production of Iron and Steel in Canada during 1918.

LIBRARY COMMITTEE.

Vol. VII MARCH, 1920 No. 3

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PAPERS AND DISCUSSIONS

This Society is not responsible for any statement made or opinion expressed in its publications

SMALL SEWAGE PUMPING STATIONS.

By Eugene F. Leger.*

(Presented before the Sanitary Section, February 11, 1920.)

Mr. Dorr has mentioned the fact that the small stations have occasioned operators some concern. They have also occasioned the manufacturer considerable concern sometimes.

Simply because a station is considered small is no reason to imagine that its problems are the more easily solved or that the equipment should be selected and installed indiscriminately. As a matter of fact, the reverse is generally the case. The larger station has a corps of men trained in the peculiarities of that station. Generally there are three shifts, so that there is constant attendance, and usually regulated means of screening the sewage, taking care of screenings, etc. Almost invariably, also, the equipment is in duplicate and sometimes in triplicate. The smaller stations, on the other hand, are often called upon to operate automatically and are practically devoid of any manual control or screening process, and are often installed in out-of-the-way places or sometimes in inaccessible places. All of these facts operate to make the proposition really more difficult in small than in large stations, and for that reason we believe even more care should be exercised in the selection of the apparatus and also in its location in the case of the small stations than in the larger stations, in spite of the fact that failure to operate, or failure of apparatus itself, might in the

* Of the Power Equipment Company, 131 State Street, Boston, Mass.

larger station cause considerably more damage than in the smaller.

The subject might be divided into two general classes or methods of handling sewage, so far as the small stations are concerned, — one the pneumatic and the other the mechanical method. The pneumatic system in this country is not quite so popular as the mechanical, for reasons I will touch upon a little later. In speaking of the pneumatic system, I will just mention that it originated in England about forty years ago, when Isaac Shone installed a system for Eastbourne. Its net capacity was 2.5 m.g.d., and it was so very simple in construction that it is almost needless to describe it; but I think, for the benefit of some of the men not acquainted with the pneumatic system, I will describe it briefly.

The system was very successful, and resulted in about six or seven installations almost immediately after it had first proven satisfactory, and in 1886 the Houses of Parliament, confronted with the very serious problem of sewage removal, commissioned Mr. Shone to investigate and install a system for handling their sewage on the strength of what he had done at Eastbourne. The requirements of this contemplated installation read very much like the ordinary specifications in sewage stations to-day, but of course at that time they probably had a good many of the bidders "stumped."

In the first place, it was required that the apparatus be automatic in operation. The requirement was also made that the cost of operation should be appreciably less than any installation requiring attendance. It was required that the equipment should operate one hundred per cent. perfect, through what we consider even to-day a very wide range of capacities, — from 50 g.p.m. to over 1 000 g.p.m. It was also required to be foolproof in construction and with a minimum of working parts. To us to-day, of course, those things are perfectly obvious. We consider that anything different would not be acceptable. But when sewage pumping stations were in their infancy this was a pretty stiff proposition. However, the installation was made, and was such a remarkable success that one of the foremost medical journals, "The Lancet," cited it as having been con-

ceived by genius. The type has been successfully used throughout the world since that time, with only minor changes with regard to air-valve control and floats and check valves. The ap-

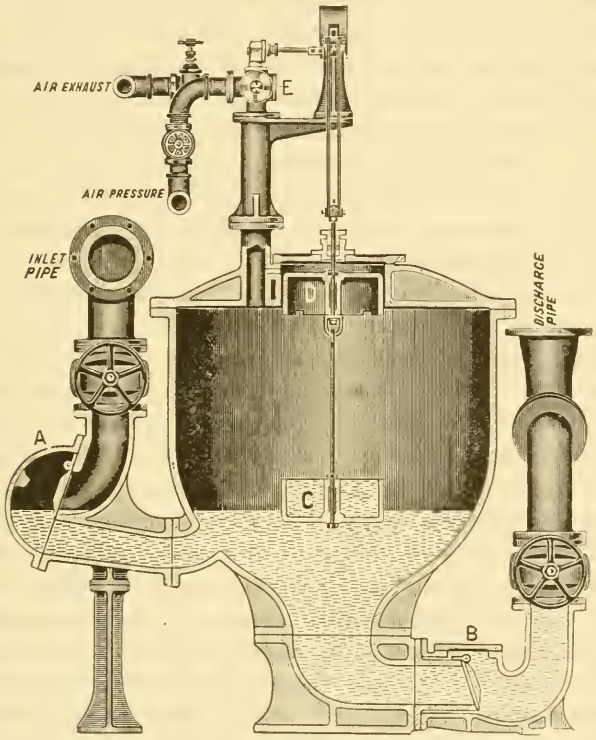


FIG. 1.—CROSS-SECTION OF SHONE EJECTOR.

paratus consists of only a cast-iron pot and connections (Fig 1). This pot has an inlet pipe and an outlet pipe near the bottom. Both of these are provided with check valves, and the pot is supplied with an inlet pipe at the top, for compressed air. The sewage flows into the pot by gravity, the tank being vented to the atmosphere during the time of filling. The float control is the most important feature. It consists of two bells on a vertical shaft which extends through the stuffing-box at the top. The bottom float is nothing but a sink pan — open and always full of water or sewage. Higher up on the float rod

is the inverted bell which serves as a positive float as soon as the water level, or sewage level, reaches the edge of the pan. The top float and bottom float are shown in the figure. As the sewage comes in, the bottom float becomes submerged, the buoyancy is immediately increased and affords a slight lifting effect to the valve mechanism on top. The sewage continues to rise, and as soon as it reaches the edge of the top float it traps the air in the float and exerts a powerful influence upon the valve at the top. This float is considerably better than the first ones used, because they were simply copper floats liable to puncture and likely to have rags hang on to them and destroy their buoyancy. This development has been made since the original installation, assuring more positive action and reliability. The sewage flows in, and when it reaches the top float the bell rises, — due to buoyancy, — trips the valve and admits compressed air and closes the vent to the atmosphere. The pressure closes the check valve in the suction line and opens the valve in the discharge, ejecting the sewage. Practically every bit of sewage in the pot is ejected at each stroke. As soon as the sewage leaves the pot the increased weight of the bottom sink pan operates to close the air suction valve and also vents the residual air to the atmosphere. The operation is intermittent, filling and discharging. The discharge stroke averages 5 to 10 seconds, and it is readily seen that anything which will flow in the pipes will be readily ejected. There are no moving parts, such as a piston or restricted areas. To our mind, this is the most simple method of handling sewage known. The cost of operation is almost four times what electrically driven centrifugal pumps cost, and for that reason it is not so universally accepted in the United States. The units are generally built in duplicate, so that the maximum capacity will generally exceed twice what the rated or nominal capacity would be.

The air for operating can, of course, come from any system of compressors in the building, or any system outside of the building. Where no such air is available, an automatically controlled compressor and tank is provided, which operates only as the demand makes it necessary. There are typical installations of this nature all over the world, — in Bombay,

India, Africa and South America. In Boston they are installed in the Board of Trade Building, the Oliver Building and in six or eight other office buildings, — at Houghton & Dutton's, Filene's, the Copley-Plaza and the Essex Hotel; at Lynn, New Bedford, Fairhaven (entire equipment) and in one section of Providence. So their feasibility and usefulness has been absolutely proven, and the only objection that has been raised is that they are more expensive to operate than electrically driven plants. There are about 40 installations of this sort in the immediate vicinity of Boston.

The second or mechanical method covers any form of pump (reciprocating or centrifugal) and any form of drive (turbine, steam, belt or motor). But the most satisfactory type by far is the electric motor-driven centrifugal pumping unit, and the reason for that is obvious. We have to-day very positive complete and highly efficient methods of electrical control. We have electric motors which are as foolproof machines as can possibly be made. We have large central stations bidding for this very class of business, and large units behind them, so that the service is practically positive; and so far as the pump end is concerned the centrifugal pump eliminates all small valves with which one is confronted in the direct-acting pump. This method also eliminates the mass of gearing and possible breakage of the triplex type. Trouble from clogging, due to the ordinarily small passages maintained in centrifugal pumps as a type, was overcome most successfully about seventeen years ago, by Yeomans Brothers in Chicago. I believe the first successful automatic centrifugal sewage ejector was installed in Chicago seventeen years ago, and it is still in use there (Fig 2). It consists of a pot similar to the Shone pot with the single exception that two pumps are provided, both taking suction from the pot, the pot acting as a receiver and the sewage flowing to it by gravity. The two pumps are connected with individual valves so that each may be cut out of service for inspection or overhauling. The pot itself is provided with a cover which carries the automatic starting equipment and which carries the vertical motor, the vertical shafts extending up to any height or down to any depth that may be necessary. The ejectors are placed in the

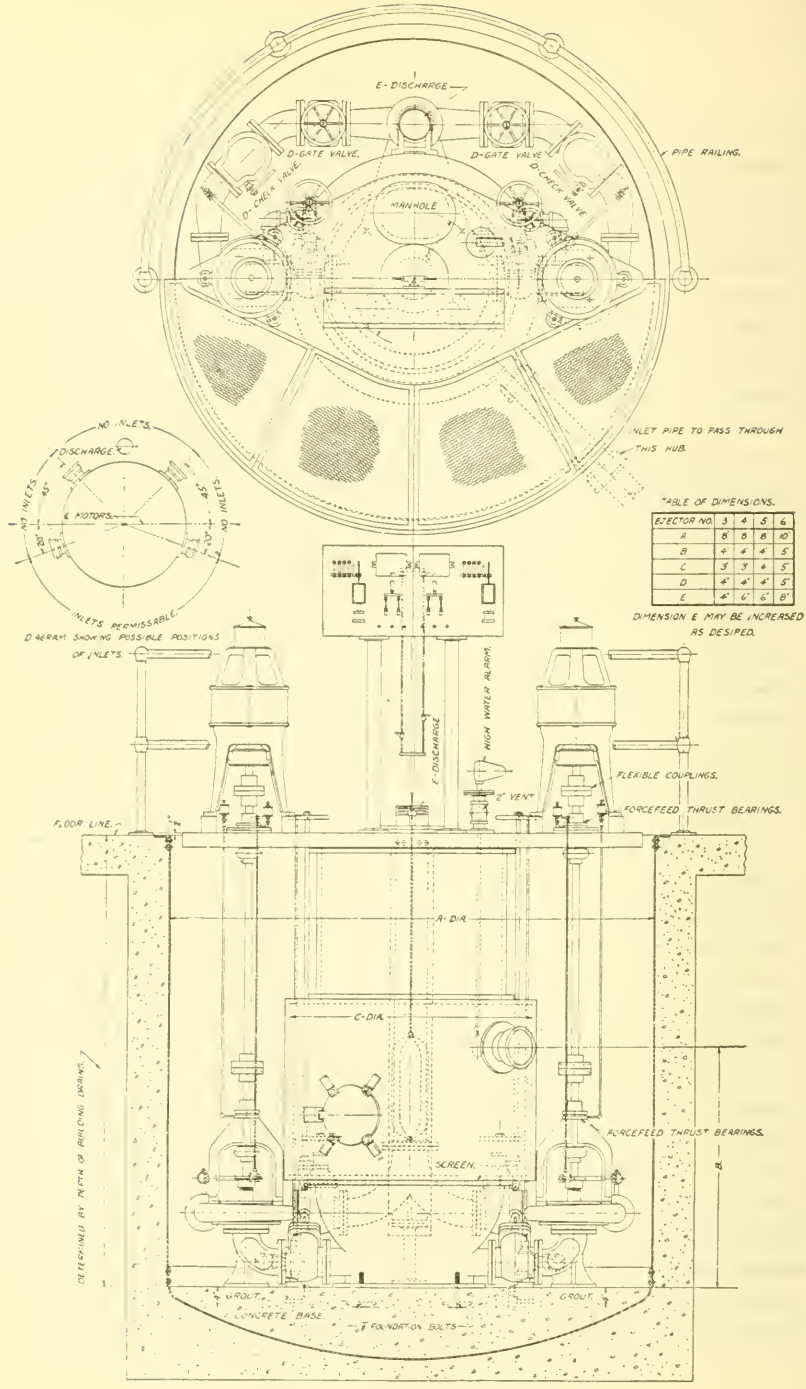


FIG. 2.—YEOMANS BROTHERS CO.—DUPLEX EJECTOR.

very lowest parts of the system so that the flow can be by gravity, and a copper float is encased in a pipe which keeps the sewage away from it. Similarly, rags, etc., are kept away from the float by encasing it in the pipe. The float rod carries two sets of tappets by which one pump is put in operation before the second, the idea being that one pump will handle all the sewage which normally flows into the pot and the second only be used in case of failure of the first, or in case of unusual flow, which is quite often the case. The pumps are of the single suction, vertical, open impeller type. These pumps are crude, however, compared with the high-grade water-works type of pump — and their ability to handle sewage is due to the fact that the passages are extremely large. The vanes are especially designed to cut or tear any rags or paper. Rags are always the bone of contention with centrifugal pumps. These vanes are designed with much different pitches and curves than in the ordinary centrifugal pump for handling water, to ensure shearing effect on rags. Each unit is provided with cut-out and check valve and the pot is provided with a grating near the bottom, which serves to catch sticks and larger particles which otherwise would normally find their way into the pump. The grating bars are never less than 1 in. and often 2 ins. apart. It is a fact also that the check valves in these electrically driven pumps are placed higher than the grating. The float starts the pump when the sewage reaches a predetermined level, and then cuts it out when another predetermined level is reached. Backflow is provided through the grating, to ensure a certain amount of water flowing back to dislodge rags, etc., from the grating, and the next charge is in an agitated condition for the pump to receive on its next start. This is considered almost absolutely necessary, because once a rag or piece of paper finds a seating on the grate it holds back a large amount of particles which otherwise would pass through the pump. The same piece of paper will often find its way through edgewise and get into the pump, where it will cause no trouble, whereas it might afford considerable trouble if left on the screen with the sewage piling on top of it. Practically no trouble has been experienced with this grating, and instances are unusual where it was necessary to clean the grating in unusu-

ally short periods. In many instances it has never been cleaned. In some instances milk-bottle stoppers and larger pieces of wood have been found on the grate. Manholes are provided in the casing, so that the grating may be cleaned. Periodic inspection is made, and it has always been shown that constant attendance is not necessary. This equipment is about as satisfactory as any which has ever been used in connection with the electrically driven type of sewage ejectors, and the fact that they have been installed in some of the largest buildings, as well as in a great many municipalities, is proof that they have always met the conditions in a thoroughly satisfactory manner, with a minimum of attendance. In a great many instances, oiling of the apparatus has been found on inspection to have been seriously neglected, simply because the man in charge has said, "Well, it runs," and consequently had never examined it or looked at it to find out why.

There is a duplex ejector of this type in Filene's basement which in one respect is very interesting. The unit is taking care of sewage — stools, etc. — at a lower level than any basement I know of — in fact, any basement about which any architect has ever consulted me. It is 73 ft. below the street level, and I think that will be a distinct surprise to most of the men here. This comprises one of the very interesting features of that installation. It has been in there ever since the building was built, and there has never been a word of complaint in regard to it. Also at the Lawton Mills there is an installation which is very interesting because of the material it has to handle. A number of different types of pumps were tried before this was installed, and since then it has given no trouble whatever. Some cities which have used this type are, Lenox; Norwood; Summer Street Extension, Boston; one section of Brookline; Fore River, Squantum (the largest of this type ever installed). This unit consists of duplex pumps, each being about 1 000 gals. per minute capacity, although never called upon to handle that amount. It is an automatic ejector and has never had an attendant other than the man to fill the oil cups. The cost of operation is about one fourth the cost of a pneumatic system.

To get down to what to me is more interesting than any of

these, because these are so old, is the development that has been necessitated by the demand for increased efficiency. The above units are both more or less inefficient. The pneumatic system, of course, is the most inefficient, and the electric sewage ejector type is also inefficient, from the fact that the pump is single suction, crudely built, with large clearances. The demand has been for more efficient methods of handling sewage, and with that in view every effort has been made to improve the efficiency by the use of the enclosed type of impeller for handling sewage. The losses were due to defective packing between the discharge volute chamber and the suction volute. This is a direct loss, and much more so than the water lost in the slippage of pumps, because the water has been through the pump once and then if it leaks back into the suction again it is a direct loss, so that the centrifugal pumps of the most efficient types are provided with wearing rings, or packing rings, or labyrinth rings, etc., between the discharge volute chamber and the suction volute chamber, to prevent this loss by leakage. One manufacturer, in his centrifugal pump for handling water, provides a most efficient form of labyrinth packing ring, — a double tongue and groove ring, — and this is one reason he has been able to guarantee 83, 84 and 85 per cent. efficiency on large units. He has also developed a closed type of impeller, for handling sewage. Immediately the small running clearances became the weakest point of the pump. These clearances became clogged with matches, rags and what we call pigtails, — yarn skeins partly wound, — and practically stopped the pump. This was the first trouble experienced, in spite of the fact that it had been considered and the packing rings had deliberately been made with large clearances and the double tongue and groove construction abandoned for the flat ring. So the first trouble on the score of clogging was between the rotating impeller and the casing. These leaks come just between the stationary casing and the rotating impeller. To overcome this, rings of a threaded form were provided which are used to-day and were first used on the Metropolitan sewerage system at Clinton. In revolving, these rings have a rotary shear effect which has kept clean the passages between the rotating impeller and the casing.

The next trouble that developed was from rags wrapping themselves around the shaft, although a lower speed was used than for water-works pumps. This was overcome by the use of stationary sleeves, in addition to ordinary bronze sleeves for protecting the shaft. These extended well into the eye of the impeller — the entrance of the impeller — so that the particles, rags, etc., which came into the pump were prevented from winding round the shaft by these sleeves. Of course, normally more or less whirlpool action is set up without these sleeves. These stationary sleeves, and sewage wearing rings, were very successful so far as they went. Additional difficulty was encountered with rags larger than the minimum passages in the impeller, with the result that the impeller was absolutely clogged practically to the periphery at the discharge. As the inlet areas are always a little bit larger than the areas at the outlet, there are in all double suction pumps more or less wedge-shaped openings. The result was that rags passed into the eye of the impeller, clogged it and dammed things behind. This was partly overcome by providing the discharge volute with three nozzles drilled into the casing, pointed in a direction opposite to the direction of rotation of the pump and connected to city water, so that when the pump began to be clogged it was shut down for an instant and the operator turned on the nozzles which rotated the pump in the opposite direction, which cleared the pump, and eight times out of ten the rag causing the trouble found its way through. However, that did not solve all of the problems, and the final solution of the whole problem was a complete change in the method of screening. Now I am talking of manual control and diverting from small stations, because the small stations are automatically controlled. This situation is interesting, however, because it shows the trend in development for higher efficiency of sewage pumps. This particular plant was of interest because it represents a step forward and shows the process of development toward that end.

As I say, the change in screening was the real solution of the whole problem. They had been in the habit of raking the screen periodically. By careful comparison of the records of the Venturi meter with the records of raking, we found the pump

began to lose capacity at the very time that those rakings took place. With this as a leader, and upon further investigations it was found as a matter of fact the raking of those screens permitted a great many rags to go through which had been caught on the screen and would normally have been taken off the screen; as it was, they passed into the pump, where with proper handling of the screens it could be prevented. So behind the regular inclined screens a second set of removable screens were dropped into place during periods of raking, to catch what would abnormally come through the first screens; and after finishing the raking, these screens were removed and simply turned backwards and cleaned with hose in a few seconds. The rakings were thrown into the suction pit and raked up with other matter. The screening problem is one, I am afraid, we are never going to get rid of if you insist on pumps of high efficiencies, because centrifugal pumps of double-suction enclosed impeller type will never have the capacity for rags, etc., that the open-type impeller has. It is expecting almost too much, I think, to hope for both maximum freedom from trouble and also maximum efficiency, and we can only look toward getting the best efficiency we can with the minimum attendance, and the question of screening is one I am afraid we are never going to get rid of completely, with centrifugal pumps.

The next plant that had serious trouble was at Swampscott, where horizontal pumps of double-suction type with stationary sleeves and enclosed type impellers are installed. Sewage is pumped from the suction reservoir, and when a level of approximately 2 ft. from the bottom is reached sludge which has been settling for a period of eight, ten or twelve hours is encountered. This gave serious trouble. It was sludge which would just flow through the pipes. In order to overcome this trouble the old vertical open impeller type of pump was retained, the idea being that pumps of high efficiency would be operated nine tenths of the time and the open impeller type one tenth of the time, when it was necessary to clean out extra heavy settled sludge. The high efficiency automatic control pumps were used for pumping down to a certain level and then stopped, the comparatively inefficient open-type impeller pump being used for handling the settled sludge.

At Brockton two antiquated reciprocating pumps had given no end of trouble, so three of the above type of unit were installed for handling, the city sewage, totaling about 3 m.g.d. It has increased since then. There is a reservoir of 500 000 gals. capacity, and during the interval of stoppage of the reciprocating pumps and the installation of the new unit the sewage settled in there for about eight months, due to delay on account of war conditions. The sewage settled for eight months in the 500 000-gal. reservoir, which was about 10 or 12 ft. deep, so when the first pump was installed and an attempt was made to lower the sewage to the point of normal pumpage, — about 2 ft. above the bottom of the reservoir, — very serious difficulty was encountered in getting the sewage out, much as at Swampscott. It was realized that the problem was a serious one, and one of the manufacturer's engineers was sent, with the idea of really learning something regarding the design of high-efficiency centrifugal pumps for that service. The result was the installation of an open-type impeller which was different from any open impeller I had ever seen, and was in fact an enclosed type, because the vanes were enclosed in walls, which makes it just as the name implies, an "enclosed type." The open type has bare vanes. The open type furnished at Brockton was one which was of vane construction, and yet there were provided stationary side plates to take the place of rotating side plates in the case of the closed type of impeller. This eliminated the wearing rings between the casing and the impeller and gave an open impeller with closed impeller features. The vanes acted as shears to cut rags, etc. That impeller was really remarkable. It handled stuff which surprised the Brockton authorities. The sewage commissioners were more than delighted with the manner in which the pump operated, and the efficiency was higher than the enclosed type which had been used for pumping relatively clear sewage. That particular feature of the open-type impeller with stationary side plates is the very latest, and, to my mind, the final solution of high-efficiency sewage pumps, with none of the disadvantages of shut-down for rags, clogging of impeller, etc. That impeller has handled the rawest and most crude forms of sewage imaginable.

The material passed was sufficient to stop the sprinkling filters. They considered their sprinkling filters about as efficient as any in the country, inasmuch as they had large nozzles capable of passing fairly heavy material which would ordinarily come to them. The system had to be shut down completely because of the unusually heavy material passing through the pump, which speaks pretty well for the pump. I believe if any one thing will eliminate troubles in the sewage pumping station it will be that type of pump with stationary shaft sleeves, to prevent rags from wrapping round the shaft; and the open-type impeller with stationary side plates, which combines the good features of the open type with the high efficiency of the closed type. Automatical control can still be maintained with such an impeller, if moderate screening facilities are provided. By "moderate" I mean screens of 2 ins. or $1\frac{1}{2}$ ins. in mesh, which will catch stones, sticks, etc. Of course it can hardly be expected that any mechanical type will handle such things as that. We must go into the pneumatic type if this is necessary. The development of that particular type of pump was a very long process but a very satisfactory one. I believe we are going to see a number of good installations with that type of pump, even with the automatic control, where screening and where attendance is going to be at a minimum. Of course there is this about the double-suction pump, — the areas are never so large as with the single-suction type. However, the increased efficiency is well worth considering, and it simply remains to be seen what we are to do in the future as regards the supplying of automatic stations with this type impeller.

The only other station I want to mention is the Calf Pasture station at Boston, which I believe is the largest sewage pumping station in the country, having a capacity around 56 m.g.d. and two units. The pumps have recently been provided with the special features I have mentioned — that is, stationary sleeves and wearing rings to cut the material which might get into the small space between the rotating impeller and the casing. This was done recently after about eight years of continuous service, and we have been told that those features have helped considerably in the cleaning, etc., of the pumps.

I will try to show you the stationary sleeves and the wearing rings provided. Fig. 3 is a vertical cross-section of the pump. *A* is the suction volute and *B* the discharge volute. The water entering the suction goes through the impeller and is discharged in space *B*. The packing is between these two spaces, — the

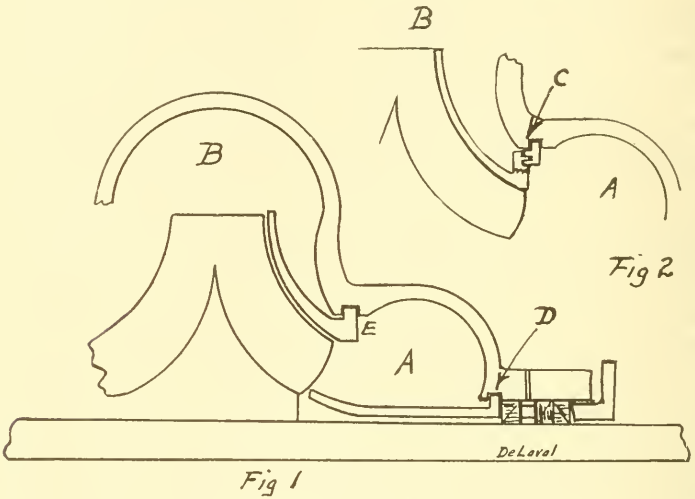


FIG. 3.—VERTICAL CROSS-SECTION OF PUMP, SHOWING SPECIAL FEATURES.

rotating impeller and the stationary casing. To pack against this leakage, labyrinth rings are provided, or flat wearing rings, with small clearance between them. The mate to the wearing ring is screwed on to the impeller, so that the water has to pass through *C* and break itself up once or twice in passing through the single tongue and groove. One manufacturer usually provides double tongue and groove. They operate with much larger clearances and less leakage. Some casings are provided with wearing rings of a flat nature, renewable, with threads cut on the flat surface, so that the tendency for any material coming into the suction, to get caught between, is eliminated. Clearances of from .03 in. to .04 in. are still maintained. The stationary shaft sleeves are simply let into the casing at *D*, to hold them stationary, and brought right up to the eye of the impeller and held there. The sewage is not brought in con-

tact with the rotating shaft at all, but kept in a constant flow condition. Of course the eye of the impeller is always greater than the area at the tip, because there are relatively low velocities here and relatively high velocities at the periphery. It is a wedge-shaped construction. Any rags might become clogged and serve to plug the pump up. At Clinton, nozzles were drilled in the casing at various points around the volute, and they tended to clean out plugged parts. Of course that meant actual hand control. It meant a man had to be there all the time to clear them out. At Brockton this open-type impeller was used. At Brockton there were two 8-in. and two 10-in. pumps, of 1.5 m.g.d. capacity, 3.5 m.g.d., respectively. The shaft carries simply a vane impeller approximately this shape. The vanes are held together with a web between them, for rigidity. There is no means of providing for leakage by the vane. Leakage does take place, except that at Brockton they put in, instead of a wearing ring, a plate, which conformed to the shape of the impeller, which is stationary. This takes the place of the wearing ring, so that the impeller really rotates in a closed space. This feature gave no clearance, and there was no clearance along the side. That was one reason better efficiency was obtained than with the regular closed type, where the pressures are greater on one side than on the other. The leakage along the inside was practically negligible. They had actual contact and wore into place, so there was practically no chance for anything to get through *E*. The pump provided had stationary sleeves. Everything is in favor of getting sewage into that impeller. There is no point where rags will wrap around the shaft; no point where leakage can get by or plugging occur, except at the tip, and there it is a question of design. It is broad enough to pass any material which will come through the pipe. There is no reason why such impellers couldn't be adapted to double-suction vertical pumps also. I will say also that three impellers of different design were made before the right design was finally hit upon, so it was a little more than simply drawing up the impeller as sketched. The eye had to be brought out into the suction volute chamber to be sure the vanes would grab rags, etc. The material pumped was practically sludge,

and was handled with a suction lift of over 23 ft., so I think we have a wonderful impeller in that particular design. When the level dropped to the last foot of the reservoir I think some 20 cartloads of coffee grounds and sand were left, which that pump had been handling. Three fire streams were used — the reservoir was 110 ft. long by 160 ft. wide — and the stuff washed into the suction pit of the pump. The invert of the sewer came into this reservoir, which had a pump pit at one end. The screens were built in a peculiar shape. They were built vertically spaced about $1\frac{1}{2}$ ins. apart along a length of some 10 ft. in two stages to facilitate handling the racks, because the distance from ground level was about 15 ft. The first platform was arranged so that a man could stand at ground level and rake and then get down on another platform. A hoist and derrick were provided to pull the stuff up. The only trouble was to keep the screens free after putting the impeller into commission. So some bars were opened in order to get heavier stuff through and ensure the pump running, whereas it could never have run even with a dozen men on the screen keeping it clean. Due to the fact that the sewer came in at one level and the overflow was 2 ft. lower, during eight months we were pumping at a level almost equivalent to that of the overflow. Sounding bars showed $7\frac{1}{2}$ ft. of solid sludge that a man could walk on, as the result of settlement. This stuff gave trouble with the impellers. Ladders were inserted through the manholes, with fire streams lashed to them, and squirted directly at the suction gate, and gradually worked that stuff ahead. We had a real problem in handling that sludge.

I don't know of any other pump that has been built with these particular features, even with the stationary sleeves along the shaft, or sewage wearing rings.

I am afraid I have deviated from the subject of small sewage pumping stations, but believe this will all tend toward the use of pumps of higher efficiency in automatic stations hereafter.

Incidentally, the pump at Brockton showed an efficiency of 76 per cent. The closed-type impeller showed 74 per cent. when they were handling practically water.

Vol. VII APRIL, 1920 No. 4

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PROCEEDINGS

PAPERS IN THIS NUMBER.

"The Application of the Perforating Process in the Preservative Treatment of Wood with Especial Reference to Douglas Fir." Edmund M. Blake.

"Wood Preservation." Lowry Smith.

"Douglas Fir as a Structural Timber." C. J. Hogue.

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Contributors are hereby notified that proof will not be submitted to them for examination unless requested before the 10th of the month preceding the month of publication.

MINUTES OF MEETINGS.

BOSTON, March 17, 1920 — The seventy-second annual meeting of the Boston Society of Civil Engineers was held at the Boston City Club, Ashburton Place, Boston, on Wednesday March 17, 1920.

The thirty-eighth annual dinner, which preceded the business meeting, was served in the auditorium of the Clubhouse at two o'clock P.M., the President of the Society, Mr. Leonard Metcalf, presiding.

There were 132 members and guests who partook of the dinner, and they were joined, before the after-dinner speaking began, by a number of other members who were not able to be present at the dinner.

The special guests of the Society and speakers were Mr. Frederick P. Fish, president of the National Industrial Conference; Mr. Richard H. Rice, general manager of the Lynn Works of the General Electric Company; and Mr. Franklin T. Miller, secretary and treasurer of the F. W. Dodge Company, Builders' Reports of Boston, who took for their subject different phases of the Labor Problem.

At 5.30 o'clock the business meeting was called to order by President Metcalf, in Rooms A and B of the Clubhouse. There were about one hundred members present.

The records of the last regular meeting and of its adjournment were read and approved. The Secretary reported for the Board of Government that it had elected to membership in the grade of Member, Messrs. Ernest D. Mortenson, Joseph Ernest Roy, Howard Moore Turner.

The Secretary announced the deaths of the following members of the Society: Joseph L. Carr, died February 24, 1920; John C. Olmsted, died February 24, 1920; and Orlando W. Norcross, an Associate, died February 27, 1920.

By vote the President was requested to appoint committees to prepare memoirs.

The annual reports were then taken up. The Secretary read the report of the Board of Government, and by vote it was accepted and placed on file.

The Treasurer read his annual report, which was accepted by vote and placed on file.

The Secretary then read his annual report, which was also accepted by vote and placed on file.

Mr. Berry, chairman of the Committee on Social Activities, presented and read the report of that committee, and by vote it was accepted and its recommendation adopted.

The Librarian submitted a report for the Committee on the Library, which was accepted and placed on file.

Mr. Sherman read a brief report of the Committee on Run-Off Available for Water-Power Purposes, and by vote it was accepted and referred to the incoming Board of Government with full powers.

By vote the reappointment of the several special com-

mittees of the Society was referred to the incoming Board of Government with full powers.

The question of the appointment of a Welfare Committee was, by vote, referred to the incoming Board of Government with full powers.

Mr. Frank A. Barbour, for the committee appointed to recommend the award of the Desmond FitzGerald medal for the best paper read before the Society during the year, in appropriate words presented medals to Edgar Sutton Dorr and Robert Spurr Weston, the joint authors of the paper entitled, " Disposal of Sewage by Treatment with Acid."

Both Mr. Weston and Mr. Dorr, in accepting the medals, expressed their sincere appreciations and thanks for the honor conferred upon them in being the recipients of this beautiful medal.

Mr. FitzGerald, through whose generosity the medal was instituted, being present, was called upon and responded in his usual happy manner.

The retiring President, Mr. Leonard Metcalf, then delivered the annual address of the president, which will be printed in the May number of the JOURNAL.

The tellers of election, Messrs. George A. Sampson and Clarence E. Carter, submitted the result of the letter ballot for officers of the Society, and in accordance with their report the President announced that the following officers had been elected:

President — Frank A. Barbour.
Vice-President (for two years) — Frank M. Gunby.
Secretary — S. Everett Tinkham.
Treasurer — Frank O. Whitney.
Directors (for two years) — John E. Carty and Henry B. Wood.
Members of the Nominating Committee (for two years) — Walter W. Clifford, Harry F. Sawtelle and Dana M. Wood.

The President then introduced the President-elect, Mr. Frank A. Barbour, who expressed his sincere thanks for the honor conferred on him in this election, and asked the members for their earnest coöperation in the work of the Society for the coming year.

Colonel Gunby in accepting the office of Vice-President promised his hearty support and best efforts in promoting the welfare of the Society.

At 6.45 o'clock the meeting adjourned to the auditorium of the Club, where the annual smoker took place. On their entrance the members found light refreshments awaiting, pipes and tobacco in abundance and a supply of paper caps of the hue which is so much in evidence on the 17th of March. Instrumental music was furnished throughout the evening by New England's Jazz-Kings, of six pieces, and the Apollo Quartet rendered a number of vocal selections which were greatly enjoyed. Another feature of the evening very much enjoyed was the dialect stories by Jack Liden, familiarly known as "Duffy," a clean-cut and wholesome American sailor, who drew many bright, new and funny stories from his well-stocked ditty bag. Four motion pictures were shown during the evening, one entitled "Through Life's Windows," another "Why We Boil Water," and two comedy pictures.

The arrangements for the smoker were in the hands of the Committee on Social Activities, and much credit is due them for the very efficient manner in which the entertainment was carried out.

The attendance at the smoker was 235, and the total attendance of members and guests at the several functions of the day was over 275.

S. E. Tinkham, *Secretary.*

Annual Meeting of the Sanitary Section.

Boston, March 3, 1920. — The annual meeting of the Sanitary Section of the Boston Society of Civil Engineers was held this evening in the Society rooms, Tremont Temple.

Commencing at 6.30 o'clock, a social hour was enjoyed. Refreshments were served by the Committee on Social Activities.

At 7.30 o'clock the business meeting was called to order by the chairman, Edgar S. Dorr.

The report of the February meeting was read and approved.

The report of the Executive Committee was read by the clerk, and was accepted and ordered placed on file.

Mr. A. L. Fales, for the Nominating Committee, presented the following nominations for officers for the ensuing year:

Chairman — Edward Wright.
Vice-Chairman — Philip W. Taylor.
Clerk — John P. Wentworth.
Executive Committee —
Charles R. Berry.
Gordon M. Fair.
Robert Spurr Weston.

The clerk was instructed to cast one ballot for the named nominees.

On motion of Mr. Chase, a rising vote of thanks was extended to Mr. Dorr for his successful work as chairman during the past year.

Following the business meeting Col. Frank M. Gunby spoke on "Living Conditions in the Orient." Colonel Gunby described the customs of the natives of the Orient and their living and sanitary conditions. The talk was illustrated by lantern slides.

Chairman Dorr introduced the new chairman, Edward Wright, who made a few remarks on the work of the Section for the coming year.

Adjourned at 7.45 P.M. Members present, 41.

JOHN P. WENTWORTH, *Clerk.*

ANNUAL REPORTS.

REPORT OF THE BOARD OF GOVERNMENT FOR THE YEAR 1919–1920.

BOSTON, March 17, 1920.

To the Boston Society of Civil Engineers:

Pursuant to the requirements of the Constitution, the Board of Government presents its report for the year ending March 17, 1920.

Membership.

The total membership of the Society a year ago was 888, of whom 791 were members, 57 juniors, 8 honorary, 26 associates, and 6 were members of the Sanitary Section only.

During the year 10 members have resigned, 20 have forfeited member-

ship for non-payment of dues, 1 junior has lost membership because of age limit, and 12 have died, making total deductions of 43.

Thirty-six members in all grades have been added during the year, of whom 8 were former members reinstated, and 6 juniors have been transferred to the grade of member.

The present membership of the Society consists of 7 honorary members, 786 members, 55 juniors, 29 associates, and 4 who are members of the Sanitary Section only, making a total membership of 881.

Deaths.

The loss by death during the year has been 12, as follows:

John A. Gould, May 18, 1919.
Charles E. Putnam, August 20, 1919.
Edward S. Shaw, October 3, 1919.
Edmund Grover, October 20, 1919.
Irving S. Wood, October 20, 1919.
Henry Manley, October 28, 1919.
Frederic P. Stearns, December 1, 1919.
Frank L. Fuller, January 20, 1920.
R. Winthrop Pratt, February 2, 1920.
Joseph L. Carr, February 12, 1920.
John C. Olmsted, February 24, 1920.
Orlando W. Norcross, February 27, 1920. (Associate.)

Remission of Dues.

Under authority of By-Law 8, the Board of Government has remitted the dues of 6 members.

Under vote of the Society passed at the annual meeting last year, the dues of 65 members have been abated in full or in part on account of war service, and under the same vote the sum of $281.69 has been transferred from the income of the Permanent Fund to the Current Fund, to make good the loss in the yearly income of the Society.

Regular Meetings.

Ten regular and two special meetings and one adjourned meeting have been held during the year.

The average attendance at these meetings was 108+, the largest being 275 and the smallest 25.

The following papers and addresses have been given:

March 19, 1919. — Address of the retiring President, Charles M. Spofford, "Reconstruction and the Engineer." Address by Gen. R. C. Marshall, Jr., on "Cost-Plus Form of Contract." Col. Frank M. Gunby, "Work of the Construction Division of the U. S. Army" (illustrated).

April 16, 1919. — Lieut.-Col. Benjamin W. Guppy, "A Year with the British Expeditionary Force." Major Lewis E. Moore, "Military Bridges." (Both illustrated.)

May 12, 1919. — Joint Meeting with the Boston Section of the American Society of Mechanical Engineers. Frederic H. Fay, Past-President, "Estab-

lishment of a National Department of Public Works," with supplementary discussions by a number of others.

June 25, 1919. — Address by Hon. William W. Blodgett, "Personal Experiences in Y. M. C. A. Work in France."

September 17, 1919. James W. Rollins, "New Boston Dry Dock." Frank W. Hodgdon, "Equipment of Dry Dock."

October 15, 1919. — Charles H. Eglee, "The Industrial Unrest."

October 29, 1919. (Special.) — Discussion on "Compensation of Engineers."

November 12, 1919. — Discussion on "Cost-Plus and Other Forms of Contract."

November 19, 1919. — George W. Fuller, "Future Opportunities and Obligations of Engineers."

December 17, 1919. — Allen Hazen, "Hydraulic Fill Dams" (illustrated).

January 28, 1920. — A. N. Johnson, "Construction of Concrete Roads" (illustrated).

February 18, 1920. — Edmund M. Blake, "Douglas Fir Industry." Chester J. Hogue, "Douglas Fir for Structural Uses." Lowry Smith, "Wood Preservation" (illustrated).

February 25, 1920. (Adjourned meeting.) — Discussion of Report of Committee on Compensation of Engineers.

Sanitary Section Meetings.

The Sanitary Section has held six meetings and one excursion during the year. The following papers have been presented at the meetings of the Section:

March 5, 1919. (Annual meeting.) — Lieut.-Col. George A. Johnson, "The Operation and Maintenance of Utilities at Army Camps and Cantonments."

May 7, 1919. — Prof. C. T. Brues, "The Sanitary Control of Mosquitoes, Flies and Other Insects."

June 4, 1919. — H. W. Rowley, "The Final Disposal of Boston City Wastes."

November 5, 1919. — Discussion, subject: "Outfall Sewers."

December 3, 1919. — Gordon M. Fair, "Recent Developments in the Use of Ultra Violet Light."

February 11, 1920. — Eugene F. Leger, "Small Pumping Stations."

The average attendance at the Sanitary Section meetings was 28.

Excursion.

On June 5, 1919, an excursion was made to the Garbage Reduction Plant at Spectacle Island.

Special Meetings for Designing Engineers.

With a view to increasing the usefulness of the Society to its younger members, a series of meetings was planned for the presentation and discussion of interesting current problems in engineering design, upon which some of these men had recently been engaged. One or two, only, of the older, more experienced members of the Society were asked to be present at the meetings, to broaden and draw out discussion and answer questions, as it was desired

to create an atmosphere which would lead the younger men into active participation in the discussion, rather than to remain silent listeners. Meetings have been held at six o'clock in the evening, the hour suggested by the men, every two weeks, alternating with the regular meetings of the Society, and have been led by the following men:

February 11, 1920. — Frank A. Marston, "Difficult Foundation Problems Involved in the Design of the New Sewage Treatment Plant at Milwaukee, Wis., and Their Proposed Solution." Discussion by Col. Charles R. Gow.

February 25, 1920. — C. A. Farwell, "Concrete Foundations at the Boston Army Supply Base." Discussion by Col. Charles R. Gow, constructing quartermaster, U. S. A., upon this work.

March 10, 1920. — Harry E. Sawtell, "The Foundations of the New Massachusetts Institute of Technology Buildings." Discussion by Col. Frank M. Gunby.

The attendance at these meetings was respectively 38, 43 and 36, and the interest has been keen. Plans have already been made for a continuation of these talks upon different subjects, and the Board of Government is considering the most effective way of carrying on this work, — by committee, as a section of the Society or otherwise.

Welfare Work.

The Society has taken an active interest during the year in welfare work.

A Committee on Compensation of Engineers was appointed to study the subject. Two special meetings of the Society were held for discussion of this subject, and the committee now has in preparation its final report. Acting upon the recommendation of the Committee on Compensation of Engineers, it is anticipated that the incoming Board of Government will appoint a Committee on Welfare.

The President and certain members of the Society appeared before the legislative committee on Senate Bill 196, bearing upon the increase in compensation of engineers in the public service.

The Society instituted a movement intended to draw out expressions of opinion from the different professional societies in Boston and vicinity, as to the desirability of some form of association or coöperation without loss of identity, that might give to the affiliated societies the advantage of increased influence in public matters, — growing out of unity of purpose and action, — and of decrease in cost of administration and maintenance, through combination and common use of certain facilities. A luncheon was held at the Boston City Club, at which representatives of seventeen organizations discussed this question, the President of your Society being elected chairman of the meeting and entrusted with the appointment of a committee of five to investigate the subject and to report its findings to the conference, with draft for form of organization which might furnish the basis of future action, should it find coöperation advantageous. The following committee was appointed; Prof. George F. Swain of Harvard University, chairman; Peter

Junkersfeld, engineering manager of Stone & Webster; I. E. Moultrop, assistant superintendent, Construction Department of Edison Electric Company; Stanley B. Parker, architect; and Beardsley Lawrence, civil engineer and secretary of the local section of the American Association of Engineers.

Your Society has also taken an active interest in the movement to convert the U. S. Department of the Interior into a National Department of Public Works, sending as its representative to the conference held in Chicago, on April 23–26, 1919, Past-President Frederic H. Fay, who was accompanied by your President, representing the American Water Works Association. Subsequent meetings of the National Department of Public Works Association were attended by these men, and two meetings of this Society were held during the year jointly, with the members of the Boston Section of the American Society of Mechanical Engineers, for the discussion of this subject, the first meeting being led by Mr. Frederic H. Fay and the second by Prof. George F. Swain, who was appointed chairman of the New England District and of the Massachusetts Committee of the National Department of Public Works Association at the suggestion of your representatives.

A representative of the Board met, in conference, representatives of the architects and of some of the labor unions of the city, upon the project for the widening of Tremont and Boylston streets on the Common. A representative of the Board also appeared before a legislative committee on the petition of the Young Men's Christian Association for authority to award certain degrees to its students.

The Committee on Matters of Interest to Engineers coming before the Massachusetts legislature has been continued during the year.

Permanent Fund.

At the February meeting it was voted to appropriate the entire income of the Permanent Fund for the current year and place the same at the disposal of the Board of Government for use in payment of the expenses of the Society so far as deemed advisable in its judgment. Under this vote the sum of $1 055.26 has been used in the payment of current expenses of the past year.

Notwithstanding the amount appropriated from the current income of the Permanent Fund of the Society for the payment of dues of war members and current expenses, there has been added to this fund during the year the sum of $385. The present value of this fund is $43 852.51, and, with the Edward K. Turner Fund amounting to $1 058.72, the permanent funds of the Society amount to the sum of $44 911.23.

Cost of Journal.

The report of the Editor of the JOURNAL for the calendar year 1919 shows that ten issues, of 1 250 copies each, have been printed, comprising a total of 682 pages. The net cost of the JOURNAL was $2 154.40, or $3.16 per page. In 1918 the net cost was $2 367.75, or $3.22 per page. The some-

what more favorable showing for 1919 was brought about largely by keeping the number of cuts at a minimum and by an increase in the amount of advertising carried. At the close of the year the amount of paid advertising space was somewhat greater than at any previous time in the history of the JOURNAL.

Award of Desmond FitzGerald Medal.

In accordance with the recommendation of the committee appointed to consider the award of the Desmond FitzGerald medal for the best paper by a member of the Society published during the year ending September, 1919, the Board has awarded the medal to Edgar Sutton Dorr and Robert Spurr Weston, for their paper entitled, "The Disposal of Sewage by Treatment with Acid."

Work of Committees.

The Board expresses its appreciation of the conscientious and effective work done by the standing and special committees. The work of the Committee on Social Activities deserves special commendation.

For the Board of Government,

LEONARD METCALF, *President.*

REPORT OF THE TREASURER.

BOSTON, March 1, 1920.

To the Boston Society of Civil Engineers:

Your Treasurer presents the following report for the year ending March 1, 1920:

Detailed data are contained in the appended tabular statements; Table 1 gives the receipts and expenditures for the year; Table 2, comparative balance sheets; Table 3, investment of the Permanent Fund.

The current expenses for the year amount to $9 811.75, being $1 170.07 increase over the preceding year.

In addition to the cash on hand at the beginning of the year, which amounted to $109.04, there has been used the sum of $1 055.26 from the income of the Permanent Fund.

The net expense of the JOURNAL has been $150.46 more than last year. The income from advertisements increased $263.50. Otherwise the JOURNAL expenses would show an increase of $413.96.

There has been an increase in the Permanent Fund of $385 after transferring from the income — which amounted to $2 264.40 — the sum of $281.69 for dues of members in the war service, and the balance, amounting to $1 982.71, to a fund to be used for current expenses.

There has been $500 invested in a 4¾ per cent. Victory Bond.

Respectfully submitted,

F. O. WHITNEY, *Treasurer.*

TABLE 1. — RECEIPTS AND EXPENDITURES.

CURRENT FUND.

Receipts.

Balance from March 1, 1919	$109.04
Members' dues	6 779.98
Members' dues paid from income of Permanent Fund	281.69
Advertisements	1 389.00
Sales of JOURNALS	180.16
Library fines	7.97
Old paper sold	5.53
Interest on bank balances	3.12
Deficit paid from income of Permanent Fund	1 055.26
	$9 811.75

Expenditures.

JOURNAL		$3 945.28
Printing, stationery, postage, etc.		955.06
Rent (net)		1 775.00
Light		63.39
Salaries (except Editor)		2 382.00
Reporting		105.50
Stereopticon		18.00
Binding		81.20
Periodicals		86.25
Incidentals		147.19
Insurance		36.83
Annual meeting and dinner		111.70
Sanitary Section, incidentals	$25.85	
Reporting	42.00	
Printing	36.50	104.35
		$9 811.75

PERMANENT FUND.

Receipts.

Cash on hand, March 1, 1919	$308.61
Entrance fees	285.00
Contributions	100.00
Interest received (net)	1 842.30
Securities to be paid for	1 128.49
	$3 664.40

Expenditures.

Coöperative bank dues	$900.00
Victory Bond purchased	500.00
Transferred to Current Fund account	2 264.40
	$3 664.40

E. K. TURNER LIBRARY FUND.

Cash on hand March 1, 1919	$69.47
Interest on bond	50.00
	$119.47
Books purchased	$54.50
Cash on hand March 1, 1920	64.97
	$119.47

INCOME FUND FOR CURRENT EXPENSES.

Interest from invested funds	$1 842.30
Coöperative banks, accrued interest	422.10
	$2 264.40
Paid dues of members in war service	$281.69
Paid deficit in current expenses	1 055.26
Balance	927.45
	$2 264.40

TABLE 2. — COMPARATIVE BALANCE SHEETS.

Assets.	March 1, 1917.	March 1, 1918.	March 1, 1919.	March 1, 1920.
Cash	$1 443.47	$478.95	$487.12	**$333.49**
Bonds and notes	33 318.75	34 835.00	35 023.00	**35 523.00**
Stock	1 950.00	1 950.00	1 950.00	**1 950.00**
Coöperative banks	4 747.15	5 930.85	7 179.65	**8 501.75**
Library	7 500.00	7 500.00	7 500.00	**7 500.00**
Furniture	2 405.11	2 405.11	2 405.11	**2 405.11**
	$51 364.48	$53 099.91	$54 544.88	**$56 213.35**
Liabilities.				
Permanent Fund	$39 888.17	$41 687.92	$43 467.51	**$43 852.51**
E. K. Turner Fund	997.87	1 023.12	1 063.22	**1 058.72**
Unexpended appropriations		105.92		**927.45**
Current funds	573.33	377.84	109.04	
Unpaid bills				**469.56**
Surplus	9 905.11	9 905.11	9 905.11	**9 905.11**
	$51 364.48	$53 099.91	$54 544.88	**$56 213.35**

TABLE 3. — INVESTMENT OF PERMANENT FUND, MARCH 1, 1920.

Bonds.	Par Value.	Actual Cost.	Value as carried on Books.
American Tel. & Tel. Co. Col. Tr. 4%, 1929	$3 000.00	$2 328.75	$2 737.50
Union Elec. Light & Power Co. 5%, 1932	2 000.00	2 050.00	2 050.00
Blackstone Valley Gas & Elec. Co. 5%, 1939	2 000.00	1 995.00	1 995.00
Dayton Gas Co. 5%, 1930	2 000.00	2 000.00	2 000.00
Milford & Uxbridge St. Ry. 7%, 1923	3 000.00	2 942.50	2 942.50
Railway & Light Securities Co. 5%, 1939	3 000.00	3 000.00	3 000.00
Superior Light & Power Co. 4%, 1931	4 000.00	3 347.50	3 347.50
Wheeling Electric Co. 5%, 1941	4 000.00	3 845.00	3 845.00
Economy Light & Power Co. 5%, 1956	1 000.00	990.00	990.00
Tampa Electric Co. 5%, 1933	2 000.00	2 000.00	2 000.00
Galveston Houston Elec. Ry. Co. 5%, 1954	2 000.00	1 940.00	1 940.00
Northern Texas Elec. Co. 5%, 1940	2 000.00	1 932.50	1 932.50
Chicago & Northwestern Ry. 5%, 1987	1 000.00	1 102.50	1 102.50
Vermont Power & Mfg. Co. 5%, 1928	1 000.00	965.00	965.00
Am. Tel. & Tel. Co. 5%, 1946	1 000.00	993.75	993.75
United States Liberty Loan 3½%, 1947	2 000.00	2 000.00	2 000.00
Am. Tel. & Tel. Co. 6%, 1925	200.00	188.00	188.00
United States Victory Loan 4¾%, 1923	500.00	500.00	500.00
	$35 700.00	$34 120.50	$34 529.25
Stock.			
15 shares Am. Tel & Tel. Co.	1 500.00	1 950.00	
Total Securities	$37 200.00	$36 070.50	$36 479.25
Coöperative Banks.			
25 shares Merchants Coöperative Bank, including interest to March		$2 730.05	
25 shares Volunteer Coöperative Bank, including interest to January		3 022.50	
25 shares Watertown Coöperative Bank, including interest to March		2 749.20	8 501.75
Total value of invested funds			$44 981.00
Securities to be paid for			1 128.49
Total value of Permanent Fund			$43 852.51

E. K. Turner Fund.	Par Value.	Actual Cost.		
Am. Tel. & Tel. Co. 5%, 1946	$1 000.00	$993.75	$993.75	
Cash on hand			64.97	
				1 058.72
Income for Current Expenses.				
Credit from Permanent Fund				927.45
				$45 838.68

We have examined the above report and found it correct.

EDWIN H. ROGERS,
JOHN L. HOWARD,
Auditing Committee of Directors of the Boston Society of Civil Engineers.

REPORT OF SECRETARY, 1919–20.

BOSTON, March 17, 1920.

S. EVERETT TINKHAM, Secretary, *in account with the* BOSTON SOCIETY OF CIVIL ENGINEERS, *Dr.*

For cash received during the year ending March 17, 1920, as follows:

From entrance fees, new members and transfer:			
23 members and associates	at $10,	$230.00	
5 juniors	at 5,	25.00	
6 juniors transferred to members	at 5,	30.00	
Total from entrance fees			$285.00
From annual dues for 1919–20, including dues from new members		$6 623.98	
From back dues		80.00	
From dues for 1920–21		76.00	
Total from dues			6 779.98
From rents			1 300.00
From advertisements			1 389.00
From sale of JOURNALS and reprints			180.16
From library fines			7.97
From sale of old paper			5.53
From contribution to building fund			100.00
Total			$10 047.64

The above amount has been paid to the Treasurer, whose receipts the Secretary holds.

We have examined the above report and found it correct.

JOHN L. HOWARD,
EDWIN H. ROGERS,
Auditing Committee of Directors of Boston Society of Civil Engineers.

Report of the Librarian.

Boston, March 17, 1920.

To the Boston Society of Civil Engineers:

The Librarian submits for the Committee on the Library the following brief report for the year 1919–20.

Because of the absence of the Assistant Librarian for the past two months and more, due to a severe sickness, not as much has been accomplished in the cataloging this year as for a number of years past, and at present only such work is going on as is deemed necessary to keep the books and periodicals accessible for the use of members.

Since the last report, 98 volumes bound in cloth and 342 bound in paper have been added to the library, making a total of 440 accessions. There are now 9 622 bound volumes in the library, and those bound in paper number a little over 3 000.

During the year 260 books have been loaned to members, and fines to the amount of $7.97 have been collected.

Twelve new standard engineering books have been added to Section 10, purchased from the income of the E. K. Turner Fund, and four others, "Building of a Wooden Ship," by T. W. Clarke; "Highways of Europe," by A. H. Blanchard; "The Turnpikes of New England," by F. J. Wood; "Vital Statistics," by G. C. Whipple, have been presented to the library by their respective authors. In addition, miscellaneous contributions of books and pamphlets have been received from the late Frank L. Fuller, G. W. Rollins, C. T. Main, L. H. Allen and others.

The amount of binding for the library done this year, while about the same as last year, is still less than usual. This is partly due to the greatly increased cost of such work and partly to the difficulty in securing complete files of some of the periodicals because of the trouble last fall in New York City with the magazine printers.

The Catalogue Equipment and Supply Company have continued keeping up to date the collection of trade catalogues placed in our library, and pocket indexes to these catalogues will be furnished to members on request.

Respectfully submitted,

S. Everett Tinkham, *Librarian.*

Report of the Executive Committee of the Sanitary Section.

Boston, Mass., March 3, 1920.

To the Boston Society of Civil Engineers:

The Sanitary Section has held six meetings, the subjects and speakers being as follows:

March 5, 1919. — Annual meeting. "The Operation and Maintenance of Utilities at Army Camps and Cantonments." Lieut.-Col. George A. Johnson.

May 7, 1919. — "The Sanitary Control of Mosquitoes, Flies and Other Insects." Prof. C. T. Brues.

June 4, 1919. — "The Final Disposal of Boston City Wastes." H. W. Rowley.

November 5, 1919. — Discussion. Subject: "Outfall Sewers."

December 3, 1919. — "Recent Developments in the Use of Ultra Violet Light." Gordon M. Fair.

February 11, 1920. — "Small Sewage Pumping Stations." Eugene F. Leger.

The average attendance at these meetings was 28.

On June 5, 1919, an excursion was made to the Garbage Reduction Plant at Spectacle Island.

Membership. — Five new members have been added during the year, making a present total membership of 169.

Special Committee. — There is a special committee on "Methods of Design and Construction and Results of Operation of Submerged Pipe Lines for Outfall Sewers." It is recommended that this committee be continued for another year.

There is also a special committee on "Methods of Design and Construction and Results of Operation of Inverted Siphons for Carrying Sewage Only and for Storm Water." Two of the members of this committee, William S. Johnson and Rufus M. Whittet have been taken away by death. It is recommended that Prof. Dwight Porter, the other member of this committee be authorized to appoint two new members to assist him in completing the work of this committee.

Respectfully submitted,
For the Executive Committee,
JOHN P. WENTWORTH, *Clerk.*

REPORT OF COMMITTEE ON SOCIAL ACTIVITIES.

BOSTON, MASS., March 17, 1920.

To the Boston Society of Civil Engineers:

The Committee on Social Activities submits this annual report for the year 1919–20.

On June 25, 1919, the Boston Society of Civil Engineers and the New England Water Works Association held the annual Field Day at Pemberton, Mass. The baseball game which was scheduled to take place between the two societies was not played because of the failure of the New England Water Works team to put in an appearance. A scrub game was substituted and was very much enjoyed by all, especially the hard-hitting portly gentlemen who were obliged to run bases often. Dinner was served in the Pemberton Inn dining-room, after which the party adjourned to the lawn, where, after a short business meeting, they were addressed by Hon. Wm. E. Blodgett, ex-mayor of Woburn, Mass. Mr. Blodgett was a Y. M. C. A. secretary in France, and brought to us a new view of the work among the boys. All of the 127 present agreed the outing a big success.

During the fall and winter months, through the generosity of one of the members, the committee were enabled to give to the members, free of charge, a luncheon and smoker before the regular meetings. The first social hour was held on November 19, 1919, at 7.00 P.M. On December 17, 1919, we started at 6.30 P.M., and on January 28, 1920, we began at 6.00 P.M. The interest continued to grow with each meeting, which necessitated the change of hour. On February 18, 1920, we started at 6.00 P.M. This was the last of these meetings and was the best attended of any, which proved to the committee that it was on the right track.

On March 3, 1920, the committee provided refreshments at the annual meeting of the Sanitary Section.

These meetings have been well attended, and the spread of good-fellowship and sociability among the members has been very noticeable. Some members who had not attended a meeting for years began to come back, and new members have been added to the Society. We believe this to be our mission, and we have endeavored to do our bit.

The committee has been asked to take charge of the Annual Smoker at the City Club this year. A good program has been arranged, and we believe every person present will thoroughly enjoy himself.

On account of the inclemency of the weather and the difficulty of transportation, no excursions have been held this year.

We wish to recommend that the Committee on Social Activities for 1920–21 be provided with sufficient funds by the Society to continue the work of promoting sociability and good-fellowship among the members.

The chairman wishes to acknowledge the hearty coöperation of the other members of the committee, A. W. Benoit, H. P. Eddy, Jr., R. W. Horne, D. Sutton and P. B. Walker, who have always been ready to help, and have contributed greatly to the success of the meetings.

Respectfully submitted,

CHARLES R. BERRY,
Chairman of Committee on Social Activities.

REPORT OF THE EDITOR.

TO THE BOARD OF GOVERNMENT, BOSTON SOCIETY OF CIVIL ENGINEERS:

Gentlemen, — The Editor submits herewith the report for the calendar year 1919.

There have been published 16 papers and 10 memoirs of deceased members.

Ten issues of 1 250 copies each have been printed, comprising a total of 682 pages. The net cost of the JOURNAL was $2 154.40, or $3.16 per page. In 1918 the net cost was $2 367.75, or $3.22 per page. The somewhat more favorable showing for 1919 was brought about largely by keeping the number of cuts at a minimum and by an increase in the amount of advertising carried.

Month.	Pages of				No. of		Cost of							
	Papers.	Proc.	Index.	Adv. (inc. Adv. Ind. and other Unpaid Space).	Inserts.	Cuts.	Papers, Proc. and Index (inc. Stock for Adv. Pages).	Inserts and Cuts.	Adv.	Reprints.	Postage, Wrapping and Mailing.	Editing.	Incidentals.	Copyright.
Jan.	24	12		14		10	$150.79	$39.62	$15.10	$16.00	$19.02		$0.71	$10.00
Feb.	42	10		14 1/8	1	3	199.54	45.57	27.01	23.00	18.90		8.16	
Mar.	72	10		17 3/4		34	297.28	135.38	41.60	81.00	19.75		.27	
Apr.	42	26		19 2/3			265.16		26.00	15.50	19.21		.52	
May	54	14		19 1/2			247.44		22.93	27.18	19.34			
June	30	14		19 1/2			169.32		17.25	32.65	18.46			
Sept.	36	14		19 1/6		8	298.54	34.31	22.75	32.87	20.12		47.50†	
Oct.	16	8		19 1/4		5	160.26	19.40	27.25	15.00	20.10			
Nov.	24	12		19 1/4			207.67		39.95	21.00	20.26			
Dec.	14	10	8	19 5/6			185.70		38.88	15.27	19.57	$450.00		
Total	354	130	8	182+*	1	55	$2 181.70	$274.28	$278.72	$279.47	$194.73	$450.00	$57.16	$10.00

Total gross cost		$3 726.06
Sale of JOURNALS and subscriptions	$86.83	
Advertisements	1 384.00	
Reprints	100.83	
		$1 571.66
Net cost		$2 154.40

* 190 pages used, not all set solid.
† Cost of wrappers for mailing purposes.

At the close of the year the amount of paid advertising space was somewhat greater than at any previous time in the history of the JOURNAL.

In October our printers revised their figures in such a way as to increase the cost of the JOURNAL approximately fifty per cent. A canvass of other printers gave but little hope that the work could be done more cheaply elsewhere, so that we are apparently faced with this increased cost during the coming year.

Our advertising rates should be increased, if feasible, to absorb as much of this increased cost as possible. It is feared, however, that by so doing we may lose some of our present clients.

The advertising situation of the JOURNAL is a peculiar one, and cannot be viewed from a strictly commercial standpoint. Many advertisers have been carrying space for years without giving much thought to the matter, and these might be lost if their attention were arrested by an increased rate. It is probable, however, that rates could be raised at this time with less danger than at any previous time.

The appended table gives, in detail, figures of cost, number of pages, etc.

Respectfully submitted,

W. L. BUTCHER, *Editor.*

APPLICATION FOR MEMBERSHIP.

[April 15, 1920.]

THE By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

CAMERON, EDWARD HUGH, Boston, Mass. (Age 31, b. Salem, Mass.). Graduate Mass. Institute of Technology, 1913, degree of S.B. in civil engineering, also a graduate of Lowell Institute in 1909, in mechanical engineering. Four years with H. P. Converse Co., as detailer, designer, estimator and superintendent of construction; two and a half years U. S. Navy, Public Works Dept., Submarine Base, New London, Conn., as chief draftsman and in charge of men of surveying work. Had charge of 21 men in the office and field, and supervised preparation of plans and field work for buildings, railroad tracks, paving, water supply systems, piers, etc. At present with Jackson & Moreland, civil engineers, Boston. Is an associate member, Am. Soc. Civil Engineers. Refers to E. P. Bliss, N. C. Burrill, J. W. Howard, L. B. Hoyt and L. J. Killion.

DAKIN, GEORGE WATERS, Boston, Mass. (Age 46, b. Boston, Mass.) Student at Mass. Institute of Technology, 1892, 1893, 1895 and 1896. Entered engineering service, sewer service, City of Boston, July, 1898, and has been continually employed in same service, as rodman, transitman, junior engineer, and since Jan., 1916, as district engineer with exception of about six months as sub-foreman on construction work, paving service of City of Boston, 1899. Has qualified under civil service for senior engineer. Now district engineer, sewer service, City of Boston. Refers to J. E. Carty, E. S. Davis, E. S. Dorr, G. W. Hamilton, E. F. Murphy and J. M. Shea.

GATELEY, FRANCIS JOSEPH, Boston, Mass. (Age 32, b. Boston, Mass.) Educated in public schools; three years civil engineering course at Franklin Union, 1914 to 1917, and buildings course at International Correspondence School, 1911–12. Rodman, sewer service, 1905–09; transitman, 1911–16, and in charge of party since 1916. Now resident engineer on Stony Brook work. Refers to T. F. Bowes, J. E. Carty, E. S. Dorr, G. W. Hamilton, E. F. Murphy and J. M. Shea.

HANNAN, WILLIAM ELLISON, Boston, Mass. (Age 46, b. Dorchester, Mass.) Graduated from Dorchester High School and then studied mathematics with tutor. With H. H. Moses, civil engineer, as rodman, 1891–92; in city surveyor's office, Boston, 1892–94, as transitman; with F. A. Foster as assistant in general engineering, 1894–96; from 1897 to 1917 in business for himself as engineer and surveyor; member Board of Street Commissioners, City of Boston, 1908 to 1911, and at present assistant enginneer in Street Laying-out Dept. of Boston. Refers to W. H. Bacon, Arthur Howland, H. C. Mildram, F. M. Miner, J. E. L. Monaghan, E. F. Murphy and F. O. Whitney.

HENDERSON, WILLIAM DAVIS, Boston, Mass. (Age 30, b. Edgewater, Staten Island, N. Y.) Graduate Tufts College 1914, degree B.S. in civil engineering. From 1914 to May, 1917, with Mead-Morrison Mfg. Co., first as office assistant, contracting department, and later as superintendent of construction of coal handling plants; June to Sept., 1917, with Roberts & Shaefer Co., Chicago, as draftsman on design and details of coal mining plants; Oct., 1917, to March, 1920, with U. S. Navy Dept., at Submarine

Base, New London, Conn., in charge of work done by day labor in connection with the construction of the base; and since March, 1920, with Jackson & Moreland, civil engineers, Boston, as field superintendent in construction department. Refers to Conrad Nolan, E. H. Rockwell, F. B. Sanborn and J. A. Tosi.

Holway, William Rea, Tulsa, Okla. (Age 27, b. Sandwich, Mass.) Graduate, Mass. Institute of Technology in 1915. With Providence Water Supply Board, 1916 and 1917; sanitary engineer at Alliance, Okla., July, 1917, to Jan., 1918; sanitary engineer, Tulsa, Okla., Jan., 1918, to Jan., 1920, and now consulting, civil and sanitary engineer, Holway Engineering Co., Tulsa, Okla. Refers to C. F. Allen, C. B. Breed, A. E. Burton, Dwight Porter and F. E. Winsor.

Johnson, William Aloysius, Dorchester, Mass. (Age 39, b. Boston, Mass.) Educated in public schools, graduating from Roxbury High in 1898, and took materials course at Franklin Union in 1910. Rodman in Street Laying-out Dept., Boston, 1898 to 1903; transitman in Sewer Dept., 1903 to 1906; junior engineer on Stony Brook Improvement, 1906 to 1909; junior engineer, Sewer Dept., 1909 to 1916; and since 1916, assistant district engineer, Sewer Dept. Refers to T. F. Bowes, E. S. Dorr, G. W. Hamilton, F. M. Miner, E. F. Murphy and F. O. Whitney.

Lennon, Arthur James, Boston, Mass. (Age 32, b. Boston, Mass.) Educated in Boston public schools, member of Class 1912, chemical engineering, Mass. Institute of Technology, but left in 1910; and also has taken buildings course in Lowell School for Industrial Foremen. Appointed rodman in sewer service of City of Boston in 1910; transitman in 1912; superintendent of the Henry Spinach Contracting Co., 1914 to 1915; transitman, sewer service 1915–16; in charge of party, Strandway Improvements, 1916–18; highway division, 1918–19; junior engineer, sewer service, since June, 1919. Refers to B. F. Bates, E. S. Dorr, G. W. Hamilton, J. E. L. Monaghan and E. F. Murphy.

Longfellow, George Perley, Boston, Mass. (Age 39, b. Haverhill, Mass.) Graduate Haverhill High School, 1900; and graduate of Haverhill Polytechnic Institute, Dept. of Engineering, 1903. On engineering service with engineers of Lawrence, Lowell and Haverhill, from 1903 to 1910; resident engineer Lockwood, Greene & Co. from 1910 to 1914; private engineering work from 1914 to 1918; on foreign service as Lieutenant U. S. Army, 1918 and 1919, and from Oct., 1919, to present time, resident engineer with Lockwood, Greene & Co. Refers to C. S. Allen, L. B. Ellis, E. R. Kimball, H. J. Reynolds, L. J. St. Amand and P. W. Taylor.

Monahan, Lawrence Joseph, Boston, Mass. (Age 51, b. Boston, Mass.) Educated in public schools, and course in structures at Franklin Union 1909–10. Has had twenty-five years' experience in engineering work and now assistant engineer, Street Laying-out Dept. of Boston. Refers to W. H. Bacon, Arthur Howland, H. C. Mildram, F. M. Miner, E. F. Murphy and F. O. Whitney.

O'Connell, James Philip, Roslindale, Mass. (Age 50, b. Cambridge, Mass.) Educated in public schools of Cambridge and Cambridge Art School. Topographical and designing draftsman for City of Boston since 1890, except two years, 1896–97, with Metropolitan Sewerage Commission, and one year with Boston Elevated Railway Co., 1898, and since 1919, asst. engineer, Sewer Dept., City of Boston. Refers to E. S. Dorr, C. S. Drake, F. A. Lovejoy, R. J. McNulty and J. E. L. Monaghan.

LIST OF MEMBERS.

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Katz, Harry L.
Leavitt, Frederick A.
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Newman, Rolf R.
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LIBRARY NOTES.

Recent Additions to the Library.

U. S. Government Reports.

Bureau of Census.

Transportation by Water, 1916.

Statistics of Express Companies, 1918.

Electrical Industries, Telephones, 1917.

Tables of Mortality from Influenza and Pneumonia, in Indiana, Kansas and Philadelphia, Pa., 1917.

National Forest Reservation Commission, Progress of Purchase of Eastern National Forest, January 1, 1920.

Report of Director General of Railroads, February 28, 1920.

City and Town Reports.

Brookline, Mass. Annual Report of Town Engineer for 1919.

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Lynn, Mass. Annual Report of Commissioner of Water Supply, for 1918.

Philadelphia, Pa. Annual Report of Department of City Transit, for 1918.

Plymouth, Mass. Annual Report of Water Commissioner for 1919.

Miscellaneous.

Life of Leonard Wood, by John G. Holme. Gift of author.

Leonard Wood on National Issue, compiled by Evan J. David. Gift of author.

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PAPERS AND DISCUSSIONS

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THE APPLICATION OF THE PERFORATING PROCESS IN THE PRESERVATIVE TREATMENT OF WOOD WITH ESPECIAL REFERENCE TO DOUGLAS FIR.

By Edmund M. Blake,* Member Boston Society of Civil Engineers

(Presented February 18, 1920.)

Introduction.

Perforating, as a process employed in the art of preserving wood, has been practiced in some form or other since the year 1838. Improvement in the method of perforating wood has been very slow. Even in recent years, up to about 1912, during which the preservative treatment of wood had shown rapid and marked development, the method of perforating had been practically neglected. As the use of more varied kinds of timber was necessitated, particularly by the railroads of the United States in order to meet their rapidly increasing annual tie requirements, timbers were encountered which did not yield to preservative treatment in the heartwood as easily as those which had first been used. Some heartwoods were even encountered which were so refractory in their resistance to preservative treatment, due to the peculiar nature of their cellular structure, that it was practically impossible to secure satisfactory penetration of the preservative, at least not without

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serious injury to the mechanical strength of the timber caused by overheating during treatment. When these conditions were encountered in commercial practice and the elements of obstruction to progress were recognized, the efforts of treating engineers were directed toward overcoming these obstacles.

While considerable progress had been recorded on the continent of Europe and in England between 1838 and 1912, a period of over seventy years, it was not until the latter year that scientific work along these lines began to shape itself definitely in the United States. In the meantime, in the treatment of railroad cross ties alone, the percentage of treated ties used in the total annual tie replacements on the railroads of the United States had increased from about 5 per cent. in 1901 to over 26 per cent. in 1912. From 1912 to 1917 important results in perforating were obtained from investigations and studies carried on in the United States. Then the European War intervened, scientific investigations outside of the urgent necessities of the war were practically abandoned and no commercial progress was made in the method of perforating. Within a few months after the signing of the armistice, the attention of treating engineers was again centered upon this important matter, and to-day machinery for the mechanical application of the perforating process is under construction and will probably be extensively used in various parts of the United States before the close of 1920. As soon as this machinery for adapting the process of perforating to the art of preserving wood is available, it is confidently expected that the scientific development of this process will be very rapid in connection with all kinds and sizes of heartwood timber.

History of the Perforating Process,

While the available records of ancient times show that the art of preserving organic bodies against decay and the protection of timber from attacks by worms were known and practiced as far back as the period during which Pliny* lived, and that various forms of preservation were used by the early Egyptians, Greeks, Britons, Dutch and Burmese, the preserva-

* 23 to 72 A.D.

tion of wood by the injection of preservative liquids did not become scientific in principle until early in the nineteenth century. Many authentic records, however, showing the gradual development of the art of preservation of timber, are available covering the period from 1657 to 1838, in which latter year Bethell patented a process for using coal tar creosote which was injected into the wood under pressure in a cylinder. It was also in the year 1838 that the first cross ties were treated in the United States for use on the Northern Central Railroad in Maryland, now a part of the Pennsylvania System. Previous to 1838 Kyan had patented an injection of a preservative into wood by pressure in a closed cylinder in 1832, and Moll had patented a process for treating wood with coal tar creosote in a closed iron vessel in 1836.

So far as the records which have been examined indicate, the first definite method of perforating timber, as an aid in the injection of preservatives, dates back to the year 1838, when a patent was granted to Earle, No. 934, on September 20 of that year. While it is recorded that Carey experimented in perforating wood before introducing the preservative in 1829, little is known of the method employed by him. In the Earle process, holes were bored axially through the timber. It is obvious that these first attempts at perforating were made on account of the obstructions encountered in the cellular structure of timber which retarded the impregnation of the preservative material under the crude processes employed during the early development of the industry.

In 1848 wood preservation was first started on a commercial scale in the United States at Lowell, Mass.

The perforating of wood by the use of holes extending radially into the timber is first indicated in the "Proceedings of the Institution of Civil Engineers," published in London in 1852 and 1853, in which the opinion is stated that when it is desirable to expedite the process of saturating wood with essential oils, it is necessary to puncture the timber with numerous small holes.

In 1875 the Louisville & Nashville Railroad built a treating plant for the commercial use of the Bethell process which laid

the foundation for the modern timber treating industry of the United States.

Following the patenting of the Rueping process in Germany in 1902, and in the United States in 1904, the development of wood preservation was very rapid, and approximately forty-five treating plants were built in this country during the period from 1902 up to 1908.

Practically all of these plants used the pressure process. Their rapid installation, indicating even more rapid increase in the demand for treated material, gave little or no time for experimental investigation of practical methods which would insure more uniform penetration of the preservative and expedite its impregnation.

It was, therefore, quite natural after all of these plants had been constructed and were in operation, together with many more plants installed in the period from 1908 to 1913, that the attention of treating engineers should again become centered upon improvements in the art of preserving wood, especially along those lines which would result in better penetration, less preservative, and reduction in the time of treatment.

On December 24, 1907, an application for a patent on a perforating process was made in the United States by Archibald R. Whitehead, an English inventor. The complete specification covering this patent was filed on June 11, 1909. The records do not show that this patent was actually granted in the United States, although the application was accepted on October 15, 1908. British creosoters had found that it was impossible to impregnate the inner portion of the heartwood of railway sleepers and telegraph poles. Whitehead stated that the oil enters the tubular cells of the heartwood at the two ends of the piece of timber undergoing treatment and flows along them for a short distance, varying in length according to the amount of pressure applied, but fails to gain admission through the lateral walls of the cells. He proposed to make a series of borings or incisions in the heartwood across the grain in such a manner as to divide each line of tubular cells into lengths short enough to allow the preservative to reach every part of its length. In order to avoid unnecessary perforations, Whitehead

proposed that each line of tubular cells should be pierced at intervals as nearly as possible equal to twice the length that the preservative would flow along such cells. The Whitehead perforations were to be arranged zigzag, not opposite to each other, and were intended only as channels or ducts leading to the cells, and he expected that the timber so perforated would not be impaired in strength, usefulness or appearance.

Two patents covering a method of perforating timber were granted in the United States to Kolossvary, Haltenberger and Berdenich, Austrian inventors from Budapest. The first one, No. 1012207, was granted December 19, 1911, and the other No. 1018624, on February 27, 1912. These two patents cover what is commonly known as the Haltenberger Process, under which experiments had been carried on in Austria since 1906. In this process the perforations in the timber were made by revolving piercers or needles which do not remove any part of the fibers of the wood, as by boring, but simply push them aside. This process was developed for use on round sticks of timber, such as telegraph and telephone poles, and the perforations made by the piercers extend in a line around the stick and are arranged in left-handed spirals.

While Rueping and others had already introduced economical methods of decreasing the cost of treatment in the case of spongy and easily treated woods, Haltenberger was trying to effect the same economy in the impregnation of harder woods and particularly of what we term the heartwood of timber. By the use of his piercers, Haltenberger created an artificial intercellular system by which he expected to regulate the results of impregnation even when the wood under treatment originally possessed intractable qualities.

On October 3, 1913, a German patent on the perforating process, No. 281793, was granted to Mr. Max Rueping.

On November 9, 1916, an application was filed in the patent office at Washington, D. C., by Oliver P. M. Goss, of Seattle, covering his claim as the inventor of an improvement in the art of preserving wood. Mr. Goss was engaged in consulting work for the Association of Creosoting Companies of the Pacific Coast at the time of the filing of this application. The Asso-

ciation was comprised of the following commerical treating companies: the Pacific Creosoting Company, Eagle Harbor, Wash.; the J. M. Colman Company, Seattle, Wash.: the St. Paul and Tacoma Lumber Company, Tacoma, Wash.: the Columbia Creosoting Company, Linton, Ore.; and the St. Helens Creosoting Company, St. Helens, Ore.

On June 15, 1917, a co-ownership contract was entered into between Mr. Goss and these five companies under which they acquired a one-half interest in his invention and any letters patent which might later be granted to him. Mr. L. J. Colman was made trustee for all of the co-owners.

On January 8, 1918, letters patent No. 1252428 were granted to Mr. Goss.

On April 26, 1919, notices were sent to the railroad and commercial treating plants of the United States over the signature of L. J. Colman, trustee, stating that he was prepared to license the use of the perforating patent at a royalty of one-half cent per cross tie and 15 cents per thousand board feet of lumber.

Serious and weighty opposition to the payment of any royalty charges under the Goss patent developed shortly after this announcement was made. Many conferences were held between the co-owners of the patent and by them with the representatives of several of the railroad treating plants. Chas. R. McCormick & Co., of San Francisco, managing operators of the St. Helens Creosoting Company, became convinced that the interests of the Douglas fir industry and the commercial creosoting plants of the Pacific Northwest would be best promoted by the elimination of all royalty charges under the Goss patent and promptly took the initiative with the object of bringing about this result. Their efforts were finally successful, and on October 6, 1919, all of the rights of Mr. Goss were acquired by the following companies and by them were dedicated on the same date to the public for general use free of cost: Pacific Creosoting Company, J. M. Colman Company, St. Helens Creosoting Company, Chas. R. McCormick & Co., St. Paul and Tacoma Lumber Company, Columbia Creosoting Company.

On December 12, 1919, a second notice was mailed by

L. J. Colman, trustee, to the railroad and commercial treating plants of the United States, canceling the notice of April 26, 1919, and stating that the Goss patent had been dedicated to the public use on October 6, 1919.

Experimental Work.

In 1902 the Rueping process patents were taken out in Germany, the rights being held by Huelsberg & Co. At the request of the Santa Fé road, this company sent a representative to the United States in the fall of 1903 for preliminary experiments with a view to adopting that process in this country. In 1904 the Rueping patents were granted in the United States and in the same year this process was exhibited at the St. Louis Exposition. In the spring of 1905 Huelsberg & Co. sent Mr. B. Kuckuck over, under arrangements with the Santa Fé, and ties treated by him with the Rueping process were placed in Santa Fé tracks in that year. Mr. Kuckuck made another trip to this country in 1906 and, following the adoption of the Rueping process by the Santa Fé road, established his residence in this country about 1910, supervising the work at Somerville, Tex., on the adaptation of the Rueping process to American practice.

It was about this time that Douglas fir cross ties were beginning to be used in large quantities by Western railroads, and no satisfactory method of treating them had been found. The temperatures required to secure even partial penetration of the oil were so high that the strength of the material was seriously impaired in treatment. By reason of their great mechanical strength and durability, however, several transcontinental railroads wished to use Douglas fir ties in parts of their Western lines, and therefore centered their attention on evolving a satisfactory method of treatment. Arrangements were made with the St. Helens Creosoting Company at St. Helens, Ore., and a series of experiments were started at that plant in May, 1912.

Mr. Kuckuck, Mr. George E. Rex of the Santa Fé, Mr. Lowry Smith of the Northern Pacific, and several other treating engineers were present at St. Helens when the test ties were

taken from the water. The results were not satisfactory with the water seasoning and, in attempting to find another solution of the problem, Mr. Kuckuck made the suggestion for the first time that perforating the ties might produce the desired results.

In September, 1912, Mr. Kuckuck, in a conference with Mr. E. O. Faulkner of the Santa Fé at Los Angeles, on the refractoriness of Douglas fir and the proposed experiments at St. Helens, suggested the possibility of using the Haltenberger perforating process which he thought might result in securing the desired penetration.

In the latter part of September, 1912, experiments were made at Albuquerque, N. M., Alamogorda and Somerville, Tex., by Mr. Kuckuck, in perforating cross ties by the use of nails and other instruments. Mr. J. L. Campbell, chief engineer of the El Paso & Southwestern Railroad, was convinced of the correctness of the principle of perforating at this time. Cross sections of some of these ties were sent back to Los Angeles with a letter from Mr. Kuckuck stating that the results were most encouraging.

In December, 1912, Mr. Kuckuck sent Mr. Faulkner a descriptive circular of the Haltenberger perforating process, and in September, 1913, sent him the complete papers and diagrams on that process.

In May, 1913, Mr. Kuckuck was placed in full charge of the experiments to be conducted at St. Helens, Ore., and in August of that year treatment tests were made on the air and water seasoned Douglas fir ties in the presence of the following gentlemen: Mr. George E. Rex, Mr. Lowry Smith, Dr. Hermann von Schrenk, Mr. F. S. Pooler, Mr. J. F. Pinson, Mr. V. C. Smith of the British India Railways, Mr. Charles Adams, Mr. Alex Lupfer and Mr. O. P. M. Goss, then in the United States Forest Service. With Mr. Kuckuck were Mr. F. D. Beal, manager, and Mr. R. H. Rawson, superintendent, of the St. Helens Creosoting Company. During the course of the experiments several of the charges contained half ties perforated on all four sides by the use of drills and other puncturing devices, with varied spacing of the holes, and Mr. Kuckuck went so far as to plot diagrams showing the spacing as suggested by him. During these tests both Mr. Beal and Mr. Rawson worked in conjunction

with Mr. Kuckuck in the investigation of the possibilities of perforating cross ties. The results obtained were again very encouraging.

In September, 1913, tests were conducted on perforated ties at Toledo for the Lake Shore Railroad; in November, 1913, at Patterson for the D. L. & W. R.R., and in March, 1914, at Adelaide for the P. & L. E. R.R.

In 1914, from April 1 to 16, experiments were conducted at St. Helens under the supervision of Mr. Goss, then with the West Coast Lumbermen's Association and the Association of Creosoting Companies of the Pacific Coast. During these experiments cross ties were perforated before treatment and later strength tests were made to determine the effect of the perforation.

In 1914, before returning to Germany, Mr. Kuckuck drew up complete plans and specifications for the application of the perforating method to cross ties, leaving copies in this country, and making application for a patent covering the Haltenberger process, the German rights on which had been purchased by Mr. Max Rueping to cover the perforating of cross ties.

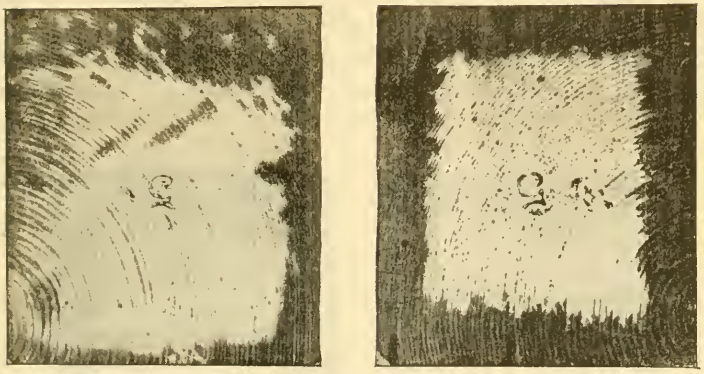
In November, 1915, representatives of the railroad treating plants and timber men, including Mr. Goss, then consulting engineer for the West Coast Lumbermen's Association, again met at St. Helens, Ore., and during this conference, which was held largely to discuss the results of the 1913 and subsequent experiments, perforating was considered as the probable solution of the Douglas fir problem, and every one agreed that this method was the only one by which a satisfactory treatment could be secured. No practicable mechanical application of the method, however, had been reached at that time.

The "Clark Machine," for perforating ties, was built late in 1915 and it was believed by the treating engineers who saw it in operation that the basic principle of the mechanical application of the perforating process had been developed by the Columbia Creosoting Company in this machine, i. e., by some form of teeth inserted in revolving drums. This machine was used in both experimental and commercial work, and again the results were very encouraging, but the consensus of outside opinion was that these results were still far from satisfactory.

In December, 1915, perforating experiments were carried on by the Pacific Creosoting Company at Seattle, in which three forms of wedges and one spike were used in making the perforations. Various arrangements of the holes were tried, the penetration being about three quarters of an inch. As only a small number of ties were used in these tests, definite conclusions could not be drawn, but very satisfactory results were indicated.

During the winter and spring of 1916, Douglas fir ties were perforated and treated in the experimental cylinder of the Northern Pacific Railroad at Paradise, Mont., and sent to Mr. Goss for compression tests perpendicular to the grain at the laboratory of the University of Washington at Seattle. These tests were made in May and July, 1916. As the temperatures used in treating the first set of ties were too high, a second set of ties were perforated and treated at a lower temperature. The tests made on this second set of perforated ties showed a strength in compression perpendicular to the grain of about 90 per cent. of the strength of the untreated tie, which indicated a combined loss of about 10 per cent., due to perforating and treatment. The perforations made in these ties were five eighths of an inch long, one eighth of an inch wide and three quarters of an inch deep, so located as to obtain a lapping of the longitudinal penetration and resulting in a solid treatment to the depth of the perforations. It was found necessary to use a chisel point that would cut the fibers the width of the tooth, otherwise the perforations would close up while being treated, seriously retarding penetration. Mr. Goss later made a series of independent tests in connection with the work done for the Northern Pacific. Figs. 1, 2 and 3 show the effects of perforations on the penetration of creosote in Douglas fir timber.

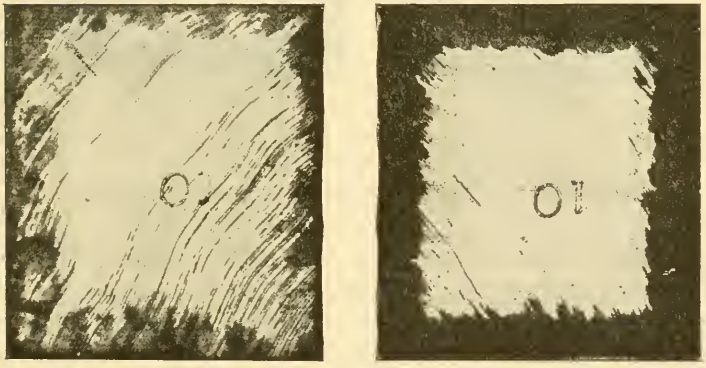
In June, 1916, tests were made at the University of Kansas on the feasibility of perforating timber by means of high voltage electricity. It was found that when the tie was placed between contacts, between which an arc was maintained in air, the area around the contacts was covered with a brush discharge which extended over the surface without producing any puncture as the voltage was raised. The conclusion was reached that such a method could not be applied practically to the perforation of timber, and these tests were abandoned.



PERFORATED. NOT PERFORATED.

FIG. 1. — PENETRATION OF CREOSOTE IN TWO PIECES OF SAME DOUGLAS FIR CROSS TIE.

Both treated in same charge during experiments in 1916.

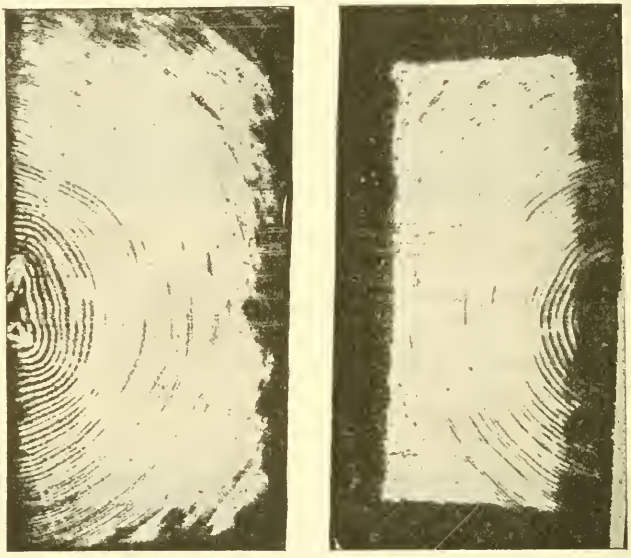


PERFORATED. NOT PERFORATED.

FIG. 2. — PENETRATION OF CREOSOTE IN TWO PIECES OF SAME DOUGLAS FIR CROSS TIE.

Both treated in same charge during experiments in 1916.

In 1917 a set of 4 x 4 ins. Douglas fir sticks, treated at the Forest Products Laboratory, Madison, Wis., by the Rueping process, were tested for strength, these tests being made to show the effect of perforations and treatment on the strength of the wood. Half of the sticks were perforated to a depth of about three



PERFORATED. NOT PERFORATED.

FIG. 3.—PENETRATION OF CREOSOTE IN TWO PIECES OF SAME DOUGLAS FIR TIMBER.

Both treated in same charge during experiments in 1916.

quarters of an inch, the holes being arranged in diagonal lines one half of an inch apart transversely and 7 ins. apart longitudinally. The penetration in the perforated sticks was complete to the depth of the holes. The unperforated sticks treated at the same time showed the usual variability and uneven penetration characteristic of Douglas fir. The completion of these experiments was interrupted by the war and no final report has yet been made upon them.

The foregoing does not pretend to be a complete chronicle of the experimental work done in the past on the perforating of

wood before treatment, but the experiments and tests recorded therein cover the principal work done along that line, which had, as its direct object, the finding of a satisfactory method of preparing Douglas fir for preservative treatment in such a way as to insure uniformity of penetration and the reduction of both high temperatures and length of treatment in the retorts with their resulting injurious effect upon the strength and durability of the wood.

Mechanical Devices.

The first machine built in the United States for the mechanical application of the perforating process was designed and constructed at the Willamette Iron Works, Portland, Ore., during the latter part of 1915 for the Columbia Creosoting Company, and was erected and placed in operation at their plant near Portland. It was quite extensively used by that company in the perforation of railway sleepers for export to the Orient in 1916 and 1917 and was also used in experimental work.

The machine consists of two horizontal and two vertical drums, in the surfaces of which are set permanent V-form rows of puncturing points. Four spiral springs hold one each of the horizontal and vertical drums against the tie as it is passed through the machine in the same general manner in which lumber is passed through a planer. The machine is operated by electricity at a speed of approximately 70 lineal feet per minute.

So far as records are available it appears that nothing further was done in the development of the mechanical application of the perforating process until October, 1919, when the Goss patent was dedicated to the public.

On December 16, 1919, a conference was held at Chicago between Mr. D. W. Edwards, of Greenlee Brothers & Co., and Messrs. George E. Rex, Lowry Smith and Edmund M. Blake, to perfect the details of the design for a new perforating machine. An order was placed the next day by Chas. R. McCormick & Co., of San Francisco, for the first machine, to be built at Rockford, Ill., for delivery in May, 1920, to the plant of the St. Helens Creosoting Company at St. Helens, Ore.

The Greenlee machine (Fig. 4) will be of particularly rugged design in view of the fact that it is to be operated under extremely severe mechanical conditions of unskilled labor, variation in the quality and sizes of woods to be perforated, the encountering of knots and more or less exposure to the weather.

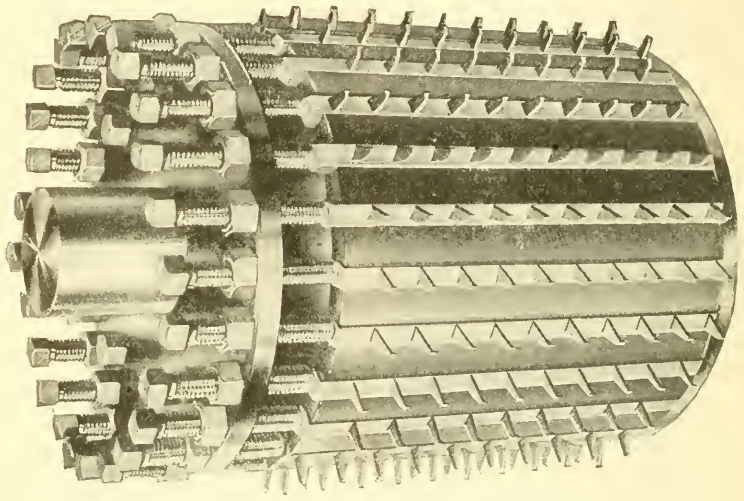


FIG. 4.—VIEW OF ONE OF THE FOUR DRUMS OF THE GREENLEE PERFORATING MACHINE.

Showing teeth and set-screw arrangement for adjusting the same. Speed of drum in operation about 70 linear feet per minute. Tooth centers 1½ ins. transversely, 2 ins. longitudinally, offset to perforate in diagonal lines.

The maximum size capacity of the machine will be for ties and timber up to 8 ins. in thickness by 14 ins. in width, the minimum thickness to which the machine will work being 3 ins. and the minimum width being 6 ins. Timbers and ties, therefore, varying from 3 x 6 ins. to 8 x 14 ins. can be perforated by this machine.

It will have a massive main frame on which will be mounted 4 perforating rolls or drums, 2 horizontal and 2 vertical. The diameter of all the drums will be 14½ ins. The width of available tooth spacing in the horizontal ones will be 14 ins., and in the vertical ones 8 ins.

The lower horizontal drum and the right-hand vertical drum, looking in the direction in which ties and timbers will be fed into the machine, will be located rigidly and both will be driven by gearing mounted upon the side of the machine arranged to receive its power from a 10-h.p., 3-phase, 60-cycle, 440-volt, A.C. motor.

The top horizontal drum and left-hand vertical drum will be flexibly and adjustably mounted for variations in the tie and timber sizes, and will furthermore be provided with flexible connections which will permit of a rocking or tilting position for perforating ties of more or less irregular form. The approximate variation of adjustments and provision for play so arranged will amount to about one half of an inch.

In addition to the four principal drums there will be provided a counterweighted, or spring actuated pressure roll, power driven from the same motor and adjustably hinged in front of the horizontal drums as an aid to the operator in lining the ties up against the rear fence as they are fed into the machine, thus assuring a straight and true feed.

The two adjustably-mounted drums will be fitted with heavy coil springs provided with tension adjustment arranged to give the necessary force to the drums for properly performing their perforating functions. The maximum pressure provided for in these springs will amount to 25,000 lbs.

Each drum will contain 25 toothways arranged to carry the teeth for perforating on approximately 2-in. distances lengthwise of the timber. The teeth will be placed in these toothways with spacing blocks for 1¼-in. tooth centers. The tooth spacers, or wedges, will be of mild steel and the teeth of hardened and tempered tool steel, designed to project seven eighths of an inch from the surface of the drum. The face of the drums will be in contact with the ties and timbers as they are passed through the machine so that the teeth will penetrate into the wood the full length of their projection from the surface of the drums.

The principal bearings of the machine will be of cast iron scraped to a smooth and perfect fitting surface, with shafts and bearings provided with oil grooves. The bearings will be fitted

with dust protecting devices and extra heavy compression grease cups of large capacity. The roll or drum shaft, on which the drums are operated, will have a diameter of 4 ins.

The speed of the machine will be about 70 lineal feet per minute, which will permit the perforating of 8 ties 8 ft. in length per minute, or about 3 800 ties in eight hours.

Forecast.

The annual cross tie requirement on the steam railroads of the United States reached the large total of approximately 119 500 000 pieces in 1916. If the annual requirements of the electric lines and private industrial tracks were added, the total would be approximately 133 500 000 pieces, representing annually over 5 000 000 000 board feet of timber. Furthermore, the number of ties treated in 1916 amounted to over 28 per cent. of the total number used. Both the production and treatment of cross ties in 1917, 1918 and 1919 were affected by the conditions brought on by the entrance of the United States into the European War. There appears to be no doubt, after business is restored to normal conditions, that the percentage of treated heartwood ties will rapidly increase, especially in view of the apparent increase in the cost of high-grade untreated ties suitable for main line use. This will call for a steadily increasing annual quantity of creosote oil and other preservatives.

During the early years of American practice, ties with a large proportion of sapwood were purchased, and zinc chloride was quite generally used as a preservative. As the cost of ties increased, a better treatment was demanded, but when creosote was introduced on a large scale the sapwood absorbed so great a quantity of the oil that creosoting under the old processes was not economical because the amount of creosote injected would preserve the tie from decay much longer than its mechanical life. This fact and the relatively limited amount of creosote oil available in this country and abroad brought American treating engineers face to face with the problem of its restricted use. Through the efforts of Mr. E. O. Faulkner of the Santa Fé Systems, the Rueping process was introduced into American practice in 1905 whereby the conservation of creosote oil became

an accomplished fact. By this process the amount of creosote oil consumed per cubic foot of timber treated can be limited to that which is required to preserve the tie throughout its mechanical life.

The next problem was that of developing a method of treating the tie with a minimum reduction in its natural strength and durability, so that its maximum mechanical life could be obtained. Here the investigators were confronted early in their experiments with the necessity of running charges through the retorts at high temperatures in order to properly impregnate the wood, with the result that the natural strength and durability of the tie was reduced from 30 to 40 per cent. during treatment. In some cases it was found that even high temperatures did not result in satisfactory impregnation on account of the refractoriness of certain woods.

The problem, therefore, became one of preparing the tie for treatment in such a way that the high temperatures and the time required for treatment in the retorts could be reduced.

It is confidently believed that the perforating process, scientifically carried out as to spacing, depth and shape of the perforations, will solve this latest problem, which at the present time confronts the treating engineers of this country, by making possible a reduction of temperature and time of treating.

It is erroneous to suppose that because the experiments on the perforating process have been largely conducted in the Pacific Northwest on Douglas fir, the value of perforating is applicable only to that timber. Obviously it will apply as well to the heartwood of any kind of timber in which it is now impossible to secure satisfactory penetration of preservative oils.

Furthermore, perforating is applicable as well to lumber for practically every use (except that in which it is subjected to loading in tension or shear), such as lumber for switch ties, sheathing, bulkheading, pontoons, marine railways, bracing, mining timbers, cross arms, sewer outfalls, culverts, etc.

Perforating can also be used on round, tapering sticks, such as poles and piling, and studies have already been started on the design of machinery to accomplish this purpose with timbers of that shape.

Its application to structural timbers for use in bridges and other structures, in which the beams are subjected to loading in tension or shear, can only be settled after thorough investigation of the effect of the perforating holes upon the tensile and shearing strength of the timber.

To summarize briefly, it is expected that perforating before treatment will accomplish the following results:

1. Control, reduction or complete elimination of checking in green ties and timber if perforating is done promptly after cutting.

2. Reduction of the temperatures required to secure satisfactory impregnation.

3. Reduction of the time required to treat ties and timber in the retorts.

4. A complete and uniform penetration of the preservative to the depth of the perforations.

5. Reduction of not over 8 to 10 per cent. in the strength of the timber in compression perpendicular to the grain. This means a reduction of the present loss in the strength and mechanical life of the treated unperforated ties or timber, which varies from 30 per cent. to 40 per cent. to a point which will balance the cost of treatment to the satisfaction of the demands of track maintenance engineers.

Some Facts on Douglas Fir — Particularly on the Production of Douglas Fir Cross Ties.

The Pacific Coast states, California, Oregon and Washington, cover an area of approximately 317 420 square miles with about 1 400 miles of coastline measured on navigation lines. In comparison, the combined areas of Illinois, Missouri, Iowa, Wisconsin, Michigan and Kentucky amount to about 332 090 square miles, and the combined areas of Alabama, Louisiana, Arkansas, Tennessee, Georgia and Mississippi amount to about 297 075 square miles. The rainfall in the three Pacific Coast states shows the greatest variation of any similar area in the United States, ranging from as high as 137 ins. annually west of the Coast Range Mountains in Oregon and Washington to

less than 12 ins. annually in southeastern Washington, central and eastern Oregon, and in the Mojave Desert and Death Valley districts of southern California. Very little snow falls and freezing temperatures seldom occur west of the Cascade and Sierra Nevada Mountains from the British Columbia line to the Mexican frontier, except in the mountain districts above an altitude of about 5 000 ft., and except at intervals of many years in the areas of lower altitude such as came during the severe storms of November and December, 1919, around the Portland district, when the Willamette River was frozen solid for the first time in the memory of the oldest inhabitants. During that storm lumber and logging operations were seriously crippled, but such extreme conditions are very rare in occurrence.

The timber stands along the Pacific Coast lie in condensed areas with quite a demarkation between the different kinds of wood, and are located approximately as follows:

Douglas fir is found, generally in very dense stands and of large sizes, running from the coast lines of Washington, Oregon and the northern half of California back to and in some cases east of the Cascade Mountains, most of the growth coming in the area of heavy rainfall. In the northern half of California it is less dense, and lies in the growth of redwood. It is also found in northeastern Washington and the eastern district of Oregon, where it is commonly known as mountain fir, and along the slopes of the Sierra Nevada Mountains in California.

Spruce is found principally in a comparatively narrow belt running along the western portions of Washington and Oregon about 20 miles inland from the coast.

The stands of white and sugar pine lie along the slopes of the Sierra Nevada Mountains running south from the Klamath Falls district in central Oregon down into the Bakersfield district in southern California.

Redwood is found only in California, with the exception of a small amount scattered in the growth of Douglas fir along the coast in southern Oregon. It appears in two forms. The stands of the variety known as *Sequoia sempervirens* occur along the coast running from the Oregon line down to the Santa Cruz district on Monterey Bay, in what is known as the "fog

belt," requiring excessive moisture for proper growth. The variety known as *Sequoia gigantea* grows in the district east of Merced along the western slopes of the Sierra Nevada Mountains, of which district the Yosemite Valley is a part. In this latter growth are found the largest trees of the world, one of which, known as the "General Sherman," is 283 ft. high, 25 ft. in diameter at the ground, and 17.7 ft. in diameter 100 ft. above the ground, the first branch being 20 ft. in circumference.

Cedar is found principally in the western portions of Oregon and Washington and scattered along the slopes of the Sierra Nevada Mountains. Western red cedar, found in Washington, is the largest of the four true cedars in the world. Port Orford cedar is widely known for its great beauty and is found in the Coos Bay district of Oregon.

Many areas of Douglas fir, redwood, spruce and pine have not yet been touched or made accessible to logging operations. This is particularly true of the stands of Douglas fir and spruce on the Olympic Peninsula in Washington, which is the area west and northwest of Tacoma. It is also true of a large part of the Douglas fir and spruce stands lying in Oregon between the Coast Range Mountains and the Pacific Ocean, especially along the Siletz and Wilson rivers. During the past year extensions of old logging roads and new logging roads have been started, in addition to those which were constructed during the war.

The Timber Resources of the Pacific Coast States.

Based upon the most reliable information obtainable, there are in the United States to-day probably about 550 000 000 acres of standing forest, including both privately owned and public lands. Of this total there are about 80 000 000 acres in the Pacific coast states of California, Oregon and Washington. Although this is a relatively small percentage, on these 80 000 000 acres it is estimated there are about 1 300 000 000 000 board feet of standing timber, which is approximately one half of the remaining supply of standing timber in the United States. About one half of this quantity, or 630 000 000 000 board feet, is Douglas fir, representing about one quarter of the total timber stand in the United States to-day.

Of the total of 1 300 000 000 000 board feet, about 340-000 000 000 are found in the state of California, about 510 000 000 000 in the state of Oregon, and about 450 000 000 000 in the state of Washington. It is interesting to note in comparison that the total stand of yellow pine in the southern states to-day, based upon figures recently compiled, is probably not much in excess of 225 000 000 000 board feet.

The following figures give an approximate idea of the relative stands in 1920 of the various kinds of timber in the Pacific coast states:

Timber.	Location.	Billions of Board Feet.
Douglas fir	California	65
	Oregon and Washington	565
Redwood	California — coast	75
White pine	California and southern Oregon	120
Sugar pine	California and southern Oregon	35
White fir	California and southern Oregon	40
Cedar	California and southern Oregon	10
Other species	California and southern Oregon	10
Spruce	Oregon and Washington	50
Cedar	Oregon and Washington	60
Hemlock	Oregon and Washington	85
Western yellow pine	Oregon and Washington	125
Western larch	Oregon and Washington	20
Other species	Oregon and Washington	40
Total stand, estimated		1 300

In connection with the stands of Douglas fir, the following table shows the proportion of public and privately owned stumpage:

Douglas Fir — Estimated Stands in 1920.

Location.	Billions of Board Feet. Public.	Private.	Total.
California	20	45	65
Oregon and Washington	98	467	565
Totals	118	512	630

The present relation between the annual production of lumber and the resources of the Pacific coast states gives an

indication of the future possibilities of that district. The three states combined, in 1918, produced about 8 500 000 board feet, and in 1919 about 8 800 000 board feet. The estimated total lumber production in the United States for 1919 is placed at about 30 000 000 000 board feet as against about 32 750 000 000 in 1918, and 36 000 000 000 board feet in 1917. The recent shortage is said to be principally in the southern pine output. The normal annual lumber export total from the Pacific Northwest is approximately 600 000 000 board feet, but the total exported in 1919 was probably less than 400 000 000 board feet, this reduction being accounted for by the conditions brought on by the war and the acute shortage of available tonnage.

It is interesting to note that the lumber mills and logging camps of Oregon and Washington gave employment to over 80 000 men during 1919, and the total pay roll amounted to about $120 000 000.

The Relation between Cross-Tie Production and the Lumber Industry.

There may be some misconception in the minds of tie manufacturers east of the Rocky Mountains as to the relation of tie production to the lumber industry of the Pacific Coast. In the southern states along the valley of the Mississippi River, in the north central states and in the east, where probably over 90 per cent. of the annual requirements in cross ties has been produced in the past, a large portion has been cut by companies organized for that purpose, whose principal business is the manufacture of cross ties. These companies vary from the larger concerns which handle the output of many tie-producing areas down to the small local companies. Large quantities of hewed ties have also been cut by individuals. In other words, in the districts east of the Rocky Mountains, tie production is quite generally a distinct and separate business by itself, although a great many ties are produced in connection with mills whose principal output is lumber in other forms.

West of the Rocky Mountains, in the states of California, Oregon and Washington, the conditions are practically reversed.

The manufacture of cross ties on the Pacific Coast up to the present time has been largely incidental to the lumber business. While the number of hewed cross ties produced annually on the Pacific Coast is small in comparison with the number of sawed ties, still a large number of split and hewed redwood and hewed fir ties are produced each year outside of the mills. There are also many tie sawmills in the Lewis River district of southern Washington and along the Willamette valley in Oregon. The tie situation, however, has been principally a lumber-mill problem of secondary importance, and the amount of future production of cross ties will depend largely upon the attitude of the lumber mills toward the manufacture of this particular railway timber product. This, in turn, will depend upon the specifications, inspection rules and prices controlling the transactions.

The production of cross ties on the Pacific Coast in 1919 probably only represented from 6 to 7 per cent. of the total lumber production, from which it is evident that cross ties to-day are a relatively small incident to the lumber industry. Probably over 90 per cent. of the Douglas fir ties manufactured on the Pacific Coast are sawed in lumber mills from logs of large dimension, because the average stand of Douglas fir trees is of large size and it has not paid to log the smaller trees except for use as piling. Therefore, the conditions and problems which are encountered in the production of cross ties on the Pacific Coast to-day are quite fundamentally different from those which influence the tie situation east of the Rocky Mountains.

Douglas Fir Ties.

The principal sources of supply of Douglas fir ties are as follows:

Washington: In the Bellingham and Everett districts on the Olympic Peninsula, in the Grays Harbor and Willapa Harbor districts, in the Lewis River district of southern Washington, along the Columbia River, and in general back to and occasionally east of the line of the Cascade Range of mountains.

Oregon: Along the Columbia River, in the Coos Bay district, along both sides of the Willamette River, and generally

in the west central areas of the state from the Willamette River to the coast line.

California: In scattering areas along the coast from the Oregon line nearly to Santa Cruz, in the Mt. Shasta region of north central California, and along the slopes of the Sierra Nevadas as far south as the Yosemite Valley district.

In connection with the use of Douglas fir it is interesting to note that the great durability and resistance to saturation by water of Douglas fir, and its great mechanical strength combined with its lightness in weight, particularly fit it for use in the form of cross ties. The unusual refractoriness of its cellular structure has, in the past, tended to limit the treatment of the heartwood with creosote oil or other preservatives, but the recent development and perfection of the mechanical perforating process assures a greatly increased use of treated Douglas fir in cross ties in the future. Douglas fir also grows very large in size and very dense in stand, and the number of hewed ties is very small, most fir ties being sawed from the logs. Structural timbers 18 x 18, running from 120 ft. to 140 ft. in length, and timbers as large as 36 x 36 and even 46 x 46, running from 50 to 80 ft. in length, are readily available. On account of its large average size, therefore, it is probable that the majority of Douglas fir cross ties will generally be manufactured from the heartwood of the timber.

Douglas fir grows under such a variety of climatic and soil conditions, that its exterior physical appearance varies considerably in different localities. As a matter of fact, Douglas fir was named after David Douglas, an English botanist, who explored British Columbia in 1825 to 1830, but, for the foregoing reason, it has been known in the past under a variety of names such as Oregon pine, Oregon fir, Washington fir, yellow fir, red fir, Douglas spruce, red spruce and Puget Sound pine. The use of so many names has been confusing and often misleading, and for these reasons the United States Forest Service has adopted the name of Douglas fir to cover the whole species, grading and density rules being applied in the selection of that kind required for particular uses.

The Production of Cross Ties in 1919.

The following tables give the estimated production of cross ties in the states of California, Oregon and Washington for the calendar year 1919, by distribution of woods and distribution of markets. Much of the information upon which these tables are based is authentic, and the figures can be depended upon as closely approximate, although in some instances it has been impossible to obtain the exact information. This is true particularly in the case of cross ties manufactured from other woods than Douglas fir, redwood and cedar. The cross-tie sizes given, so far as it has been possible to obtain them, may be considered as indicating the market range in dimensions, the greatest range coming in ties manufactured to meet the demands of foreign markets:

Estimated Production of Cross Ties in California, Oregon and Washington for the Year 1919. (E. & O. E.)

Distribution by Markets.

Douglas Fir.	Number of Pieces.	
For Pacific Coast railroads		
7″ x 8″, 7″x 9″, and 7″ x 10″ x 8′		5 710 000
For Inland and Eastern railroads — by rail		
7″ x 8″ x 8′	700 000	
7″ x 8″ and 7″ x 9″ x 8′ 6″	3 150 000	3 850 000
For Inland and Eastern railroads — by vessel		
7″ x 8″ x 8′ 6″	306 250	
7″ x 9″ x 8′ 6″	918 750	1 225 000
For Export — To United Kingdom		
4½″ x 9″ x 9′	1 900	
5″ x 10″ x 8′ 6″	212 500	
5″ x 10″ x 9′	1 362 000	
5″ x 12″ x 8′ 6″	3 000	1 579 400
To West Coast of So. America		
4″ x 6″ x 4′ 6″	15 100	
6″ x 8″ x 8′	31 100	46 200
To Mexico		
6″ x 8″ x 6′	2 100	1 627 700
Estimated total for Douglas fir		12 412 700

Redwood.	Number of Pieces.	
For Pacific Coast railroads		
6″ x 8″ x 6′	8 000	
6″ x 8″ x 8′	78 000	
7″ x 8″, 7′ x 9″ and 7″ x 10″ x 8′	2 489 000	2 575 000
For Export		
To West Coast of So. America, etc.		
6″ x 8″ x 8′		200 000
Estimated total for redwood		2 775 000
Cedar.		
For Pacific Coast railroads		
Mostly 7″ x 8″ x 8′		175 000
Yellow Pine, Western Larch, Western Spruce, Western Hemlock and Other Kinds.		
For Pacific Coast railroads		
7″ x 8″, 7″ x 9″ and 7″ x 10″ x 8′		250 000

Estimated Production of Cross Ties in California, Oregon and Washington for the Year 1919.

(E. & O. E.)

Summary by Kinds.

	Pieces.
Douglas fir	12 412 700
Redwood	2 775 000
Cedar	175 000
Other kinds	250 000
Estimated total production, 1919	15 612 700

Summary by Markets.

All Kinds and Sizes.

	Pieces.
For Pacific Coast railroads	8 710 000
For Inland and Eastern railroads by rail	3 850 000
For Inland and Eastern railroads by vessel	1 225 000
For export	1 827 700
Estimated total production, 1919	15 612 700

The Possibilities of the Future.

Quantity production of Douglas fir cross ties in Oregon and Washington is capable of almost unlimited increase in the future providing the conditions controlling production are favorable. These conditions are based fundamentally upon a purchase price balanced with the requirements of both specifications and inspection rules. It is anticipated that the use of Douglas fir lumber will steadily increase to meet both domestic and foreign demand, and if heartwood cross ties of close-grain wood are called for in future specifications their price again must be rationally balanced with the market for the higher-priced lumber products, inasmuch as these lumber products, bringing the higher prices, can be cut by the mills from the same logs which would be used in the manufacture of the majority of cross ties.

As the quality specified and the consequent cost of cross ties has advanced, it has been a matter of prudent economy to give them some form of preservative treatment in order to get the maximum life out of the higher-priced tie. Thus it is that sapwood ties are rapidly going out of use and heartwood ties are taking their place at the higher price which heartwood commands.

In conclusion, the railroad cross ties produced on the Pacific Coast have been largely a by-product of the lumber mill. In logging operations to-day the smaller growth is left untouched except as removed for piling. With an increased demand for cross ties, however, this smaller growth will doubtless be hewed into ties or cut up in portable or small permanent tie sawmills. Therefore it is quite entirely within the range of possibility that tie production on the Pacific Coast may become in the future a distinct and separate business of itself, as it is east of the Rocky Mountains, correlated with but independent of the lumber mill, and in the wake of the larger lumber logging operations the great forest areas of the Pacific Northwest may offer employment to thousands of laborers in the splitting and hewing of cross ties from the smaller growth and in the lesser logging operations connected with portable or small permanent tie sawmills. What-

ever form the production of cross ties on the Pacific Coast may take in years to come, it is undoubtedly the destiny of Douglas fir to fill the most important part, representing as it does about one quarter of the total stand of timber in the United States to-day. Mechanically perforated promptly after its manufacture to control or prevent checking, to hasten air seasoning and to insure a uniform predetermined penetration of preservative, then economically treated with the maximum conservation of oil possible and with the vitally important reduction of time and temperature made possible by perforating, it is doubtful whether any cross-tie timber will give a better account of itself in the track bed than Douglas fir.

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WOOD PRESERVATION.

By Lowry Smith.*

(Presented February 18, 1920.)

Many things during the past two years have tended to increase the general interest in wood preservation. The rapidly diminishing supply and greatly increased cost of the more durable woods, together with the high cost of replacement and labor problems, have brought very forcibly to the attention of users of wood the necessity of adopting means of utilizing the less durable woods that possess the requisite mechanical properties, and also of insuring a much greater permanency to whatever kind of wood may be used.

Wood possesses many qualities that make it the most desirable material for many classes of construction, its greatest shortcoming being in the unbalanced relation that exists between its mechanical and physical properties. Wood preservation might be defined as the art of balancing these properties; in other words, the art of imparting to wood the ability to resist decay or destruction by other causes, throughout its mechanical life, in the capacity for which it may be used.

Wood, in common with other organic materials, is subject to deterioration due to many causes, the ones most commonly encountered being decay, attacks of certain animal life and fire. Wood preservation deals with the two first. Fireproofing, while an allied subject, is not of such general interest.

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Research of comparatively recent date has shown decay to be due to the action of low forms of plant life known as "fungi," and not to fermentation of the sap or action of the soil, as was the popular opinion. These fungi subsist on the wood by changing it into food through exuding substances that dissolve certain constituents of the wood fiber. This action changes the color of the wood and so weakens the structure that it becomes soft or crumbly, taking the form known as rotten wood.

Evidence that wood is being attacked by fungi may be seen in the form of growths commonly known as "fungus," "punks," "dog ears," "toad stools," etc., which appear upon a surface. These external growths are the fruiting bodies (corresponding to the bloom or seed pod of a plant) of the fungus, and their functions are to produce spores or seeds which are disseminated by the wind or other mediums. Whenever these spores alight on wood where conditions are favorable, they germinate in the same manner as the seed of a plant, and grow into the interior of the wood, destroying its structure as they progress. In addition to spreading by means of the dissemination of the spores, fungi extend themselves from one piece of wood to another by growing over small intervening spaces. Decay, it is seen, is infectious, and decaying wood is a menace to all wood in its vicinity.

The exterior growths on fruiting bodies are not the destroying agencies of the fungus, and the action of the fungus is not stopped by removing these fruiting bodies as some seem to believe, but where found show that the fungus has reached an advanced stage in the interior of the wood.

To develop, fungi require the same things as other forms of plant life, — that is, food, air, moisture and heat. Warm, damp locations are most favorable to their growth. If they can be deprived of one of these essentials they cannot exist. Since the control of the air, moisture and heat when wood is used out of doors is impracticable, the surest way to stop fungi is to inject into the wood substances that poison their food supply.

The destruction of wood due to various forms of animal life is by no means so great as that due to decay, nevertheless it occupies a very important position in the general subject. The

most commonly encountered destruction of this character is that of piling and other construction timbers, where used in salt water, by marine borers such as teredo and limnoria, and that of various forms of construction timbers by termites or white ants.

Woods available for use in the United States vary greatly in their resistance to decay. The sap portion of all woods will soon decay when exposed to the weather, but the heart portion of some woods is quite durable.

The diminishing supply and high prices of the durable woods in many cases dictate the use of woods not so durable but which possess the necessary mechanical values, and to which resistance to decay can be imparted by preservative treatment. This feature of wood preservation deserves great consideration not only from the viewpoint of economy but also from that of the conservation of our timber supply.

In the past it has been considered that the greatest economy could be effected by confining preservative treatment to the non-durable woods possessing the necessary mechanical properties, due to the fact that they could be purchased at a comparatively low cost. However, due to the deterioration in the quality of the durable woods now obtainable, the timbers from which almost invariably contain quite a large percentage of sap wood, preservative treatment of them as well is now considered good practice.

Some idea of the value of preservative treatment can be had from the knowledge that cross ties which untreated will totally decay in three to seven years, last ten to sixteen years when treated; that piling and timbers which untreated will decay in six to twelve years, last fifteen to thirty years when treated; that piling and timbers which untreated will be destroyed by marine borers in one to four years, last twelve to twenty-five years when treated.

Contrary to the general idea, the art of wood preservation is by no means new, although its greatest progress has been made within recent years. That the ancients practiced it is revealed by Pliny who says they protected wood from attacks by worms by treating it with garlic boiled in vinegar. The

embalming of their dead by the Egyptians is well known to all. The Greeks and Romans recognized the value of certain oils for preserving the wood they used in buildings. The Britons used to preserve the timbers of their warships against decay, either by soaking them in or coating them with linseed oil, tar, etc. The Dutch early learned the value of preserving the timbers used in the construction of their dikes and marine structures. All of the early methods were very crude and did not get enough penetration of the preservative to have any great value other than that of shedding water. It was not until the early part of the nineteenth century that the preservation of wood by the injection of chemicals under pressure became scientific in principle and received any great degree of development.

Many patents covering methods and mediums for preserving wood have been issued both in this country and abroad, and earlier methods have been steadily improved. The mechanical operating features of the processes have also been greatly improved, and the aim of the art to-day is to see that only sound wood in proper condition be treated, and that the necessary protection be afforded with the use of as little preservative as will assure efficiency.

The growth of wood preservation in the United States from 1838, when the first cross ties were treated by the infusion of bichloride of mercury and laid in the track of the Northern Central Railroad, in Maryland, now part of the Pennsylvania System, has been extraordinary. It can best be judged by the fact that in 1900 there were only 15 wood-preserving plants, and that the total number of cross ties treated during that year was only 2 800 000, while in 1919 there were about 100 plants and the number of cross ties treated was over 35 000 000. The increases in the other classes of material treated has been proportional. The first commercial wood preserving plant in the United States was built at Lowell, Mass., in 1848, using alternately bichloride of mercury and chloride of zinc, and it is believed to be in operation at the present time.

The proper preparation of wood for treatment is essential, and it is the recognition of this fact and the improvements made

in connection with it that have been among the most important advances made in the art of wood preservation during recent years. Wood when green contains much moisture which resists penetration of the preservative and must be reduced in volume before successful treatment can be accomplished. This is accomplished by several methods, the most preferable of which is air-seasoning. Kiln-drying or steaming may also be resorted to, as also may be boiling in hot oil. The method depends somewhat on the kind and condition of the wood, but largely on personal preference. With any method and for any kind of wood the first step in its preparation for treatment is the removal of all the bark. When wood is prepared by air-seasoning it is stacked on well-drained ground, free from vegetation, in open piles. The seasoning period varies with many conditions, such as locality, time of the year, kind and condition of wood, and the size of the pieces. It generally varies from four to twelve months. To avoid severe checking, the piles in arid regions should be less open than in humid regions. Certain kinds of wood are apt to split severely while seasoning, but this can be largely overcome by driving into the ends of the timbers irons of proper shape. Wood which is to be air-seasoned should preferably be cut during the winter, as spring and summer are the best seasoning periods.

When air-seasoning is not feasible, steaming is usually resorted to, in which case care must be exercised that the temperature and its duration are not carried to the point of reducing the strength of the wood. After steaming, a vacuum is applied to dry the wood as much as possible.

On the Pacific Coast, in the treatment of Douglas fir, boiling in creosote oil is generally practiced. Recently a process for perforating the surfaces of the wood has been developed, and its use in connection with air-seasoning is expected to take the place of boiling, at least in the case of cross ties and certain structural timbers.

Preservative treatment will not remedy physical or mechanical defects of any kind, consequently only wood which is free from decay, or which has no knots, splits, shakes or other faults of sufficient size or number to weaken it for the purpose

for which it is intended, should be treated. Timber which has to be bored, chopped or otherwise cut into during its erection should be so framed before treatment. The boring of cross ties for the insertion of spikes and the gaining of seats for the plates, before treatment, is being practiced by many railroads at the present time.

The degree of treatment to be given varies with the kind and character of the wood and the purpose for which it is to be used. In all cases the sapwood should be thoroughly penetrated by the preservative, as sapwood is always that portion of wood first affected by decay. Penetration of the heartwood is also very desirable and should be as complete as practicable for the kind of wood used.

Inventors have been busy for years endeavoring to find ways and means for protecting wood against decay and other forms of destruction. Many processes and preservatives have been brought out and demonstrations made to prove their worth, but very few of them have been commercial successes.

A wood preservative's value is determined primarily by its toxicity, permanency, and water-shedding qualities. The toxic values of preservatives vary greatly, and the greater their toxicity and permanence the longer they will prevent decay. Toxic preservatives that will easily penetrate wood, that are permanent, that do not affect its strength, and that are obtainable at a reasonable price, are most efficient and economical.

A large number of substances have been proposed as means of preserving wood, but out of the lot only creosote oil and zinc chloride have come into general use in the pressure processes. Sodium fluoride has shown very promising results, and in some ways would seem to be the most desirable of the water-soluble preservatives. However, its use has not been general or long enough to justify, in the minds of many, ranking it with zinc chloride. Creosote oil is the most important of all wood preservatives, and as recognized by the wood preserving industry is derived from the destructive distillation of coal tar and consists of the fractions distilling off between 200 degrees and 400 degrees Cent.

The amount of creosote oil used in the pressure processes

varies from 5 to 24 lbs. per cubic foot of wood, the maximum quantity being used where it is desired to protect wood from the attacks of marine borers.

Zinc chloride is the principal water-soluble preservative, and is used principally for localities that are not excessively wet or where low first cost is essential. The use of one-half pound of zinc chloride per cubic foot of wood is considered good practice.

The processes of commercial importance that are used in preserving wood are divided into two general classes, the first being non-pressure processes which coat the wood with a superficial absorption, and, second, pressure processes that impregnate the interior of the wood with the preservative injected under pressure. The non-pressure processes are divided into three classes; and first being the simplest and oldest form of wood preservation, which consists of applying the preservative with a brush, using as many coats as considered desirable. Spraying is sometimes used as an alternative. The penetration resulting from these methods is very slight. The second class consists in soaking the wood in hot or cold preservative. This results in a penetration greater than that obtained by brushing or spraying. The third and best class consists of placing the wood in hot preservative for a proper time, after which it is removed and plunged into cold preservative. This results when properly manipulated in by far the best penetration obtained by any of the non-pressure processes, and it is used extensively for the butt treatment of poles and posts. Where only small lots of material are to be treated and the treated wood will not be abraded or split through the coating of preservative, these processes are economical if properly carried out. The best results from non-pressure processes are had only when thoroughly-seasoned wood is used. The results obtained from the use of non-pressure processes are not comparable with those obtained from the use of the pressure processes, and it should be understood that the non-pressure processes are makeshifts and should not be considered in the same class with the pressure processes.

The pressure processes are used wherever large quantities

of material are treated, and obtain deep penetration of the preservative, thereby insuring maximum protection. The depth of the penetration obtainable is dependent upon a number of factors, chief among which are the kind of wood, its moisture content and method of treatment. The almost universal method of impregnating wood with a preservative is by the pressure processes. These processes are carried on in cylinders which range from 72 ins. in diameter and 42 ft. long to 108 ins. in diameter and 172 ft. long, and in which the preservative is forcibly injected into the wood under pressure by means of pumps. The pressure processes are divided into two classes, the first being full-cell treatments, which force into and leave in the wood practically all the preservative it will hold where penetrated, thereby giving maximum protection against decay or attack by animal life for that depth of penetration; the second being empty-cell treatments which aim to reduce materially the final retention of preservative while not reducing the depth of penetration.

The better-known pressure processes used in the United States are:

Bethel (full-cell process).
Lowry (empty-cell process with final vacuum).
Rueping (empty-cell process with internal air pressure and final vacuum).
Burnett (zinc chloride).
Card (zinc chloride and creosote oil).

Complete specifications for these processes as issued by the United States Railroad Administration, Forest Products Section, appear as an appendix to this paper.

In addition to the processes, there are in use on the Pacific Coast for the treatment of Douglas fir the following processes:

Boiling — consisting essentially of the following steps:

Wood (either green or seasoned) in the treating cylinder is immersed in creosote oil.

Oil heated to 225 to 250 degrees Fahr. at atmospheric pressure, and vapors passed through a condenser.

Heating continued until the rate of condensation falls to one sixth to one tenth of a pound of water per cubic foot of wood per hour. This frequently requires forty to sixty hours for green timbers, and sometimes more.

Cylinder filled with cool oil, allowing temperature to fall.

Pressure applied, maximum 120 to 150 lbs. per square inch, until desired injection of preservative is obtained.

Boulton (boiling under vacuum) — consisting essentially of the following steps:

Wood (either green or dry) in the treating cylinder is immersed in creosote oil.

Oil heated to 190 to 210 degrees Fahr., and subjected to a vacuum, the escaping vapors passed through a condenser.

Heating continued until the rate of condensation falls to one sixth to one tenth of a pound of water per cubic foot of wood per hour.

Cylinder filled with cool oil, allowing temperature to fall.

Pressure applied, maximum 120 to 150 lbs. per square inch, until desired injection of preservative is obtained.

The advantage of a Boulton over a Boiling process lies in the fact that the vacuum during the boiling permits the distilling off of the moisture in the wood at much lower temperature which results in less damage to the wood by heat.

There are many other processes, the merits and demerits of which have been or are yet to be demonstrated.

APPENDIX.

UNITED STATES RAILROAD ADMINISTRATION.
DIRECTOR GENERAL OF RAILROADS.

SPECIFICATION FOR THE PRESERVATIVE TREATMENT OF WOOD WITH CREOSOTE OIL.

(Empty-cell Process with Final Vacuum.)

Except when ordered otherwise by the railroad's representative, the material to be treated shall be air-seasoned until in his judgment any moisture in it will not prevent injection of an adequate amount of preservative; shall be confined in any charge to woods into which approximately equal quantities of preserving fluid can be injected; and shall consist of pieces approximately equal in size and sapwood content, on which all framing, boring or adzing shall have been done, so separated as to insure contact of steam and preservative with all surfaces.

The preservative used shall be the one most suitable and available of the following standards of the American Wood-Preservers' Association:

"Creosote Oil, Grade 1, for Ties and Structural Timber."
"Creosote Oil, Grade 2, for Ties and Structural Timber."
"Creosote-Coal-Tar Solution for Ties and Structural Timber."
"Creosote Oil, Grade 3, for Ties and Structural Timber."

The material shall retain an average of at least 6 pounds of creosote oil per cubic foot for cross ties and 10 pounds per cubic foot of other material, and no charge shall retain less than 90 per cent nor more than 110 per cent of the quantity per cubic foot that may be specified. The quantity of preservative retained shall be calculated, on the basis of 100° F., from readings of working-tank gauges or scales or from weights of at least one-tenth of the material on a suitable track scale before and after treatment, checked as may be desired by the railroad's representative.

After the material is placed in the cylinder, the preservative shall be introduced, at not over 200° F., until the cylinder is filled.

The pressure shall be raised and maintained until there is obtained the largest practicable volumetric injection that can be reduced to the required retention by a quick high vacuum. The pressure and temperature within the cylinder shall be so controlled as to give the maximum penetration by the quantity of preservative injected. After the pressure is completed the cylinder shall be speedily emptied of preservative and a vacuum of at least 22 inches promptly created and maintained until the quantity of preservative injected is reduced to the required retention.

At least once each day the railroad's representative shall determine penetration by sampling ties at middle and rail sections; from other material samples shall be taken as desired. Any holes that may be bored shall be filled with tight-fitting creosoted plugs.

The treating plant shall be equipped with the thermometers and gauges necessary to accurately indicate and record conditions at all stages during the treatment, and all equipment shall be maintained in condition satisfactory to the railroad. The owner of the treating plant shall also provide and keep in condition for use at all times the apparatus and chemicals necessary for making the analyses and tests required in this specification.

Approved:
W. T. Tyler,
Director of Operations.

Approved:
H. B. Spencer,
Director of Purchases.

Washington, January 1, 1919.

United States Railroad Administration.
DIRECTOR GENERAL OF RAILROADS.

SPECIFICATION FOR THE PRESERVATIVE TREATMENT OF WOOD WITH ZINC CHLORIDE.

Except when ordered otherwise by the railroad's representative, the material to be treated shall be air-seasoned until in his judgment any moisture in it will not prevent injection of the specified amount of preservative; shall be restricted in any charge to woods into which approximately equal quantities of preserving fluid can be injected; and shall consist of pieces approximately equal in size and sapwood content, on which all framing, boring, or adzing shall have been done, so separated as to insure contact of steam and preservative with all surfaces.

The zinc chloride used shall be acid-free and shall not contain more than 0.1 per cent iron. Dry zinc chloride shall contain at least 94 per cent soluble zinc chloride, and in any solution purchased the percentage of zinc chloride specified shall be the amount of soluble zinc chloride required.

The material shall retain an average of 0.5 pound of dry zinc chloride per cubic foot, which shall permeate all of the sapwood and as much of the heartwood as practicable, and no charge shall retain less than 90 per cent nor more than 110 per cent of this quantity.

The treating solution shall be no stronger than necessary to obtain the required retention of preservative with the largest volumetric absorption that is practicable, and shall be thoroughly mixed before use. Its strength shall not exceed 5 per cent and shall be determined by analysis. Chemical titration, using a silver-nitrate solution with potassium-chromate indicator, will usually be satisfactory. For example: With red oak the strength shall not exceed

4 per cent, and the volume injected shall be not less than 20 per cent, while with pine having a large percentage of sapwood it shall not exceed 2 per cent, and the volume injected shall be not less than 40 per cent. The amount of solution retained shall be calculated from readings of working-tank gauges or scales or from weights of at least one-tenth of the material on a suitable track scale before and after treatment, checked as may be desired by the railroad's representative.

Air-seasoned material shall be steamed in the cylinder for not less than one hour nor more than two hours, at a pressure of not more than 20 pounds per square inch, the cylinder being provided with vents to relieve it of stagnant air and insure proper circulation of the steam and being drained to prevent condensate from accumulating in sufficient quantity to reach the material. After steaming is completed, a vacuum of at least .22 inches shall be maintained until the wood is as dry and as free from air as practicable. Before the preservative is introduced, the cylinder shall be drained of condensate, and if the vacuum is broken, a second one as high as the first shall be created. The preservative shall be introduced, without breaking the vacuum, until the cylinder is filled. The pressure shall be gradually raised and maintained at a minimum of 125 pounds per square inch until the required quantity of preservative is injected into the material, or until less than 5 per cent of the total quantity required has been injected during the latter half of one hour throughout which the rate of injection has persistently decreased while the pressure has been held continuously at 165 or more pounds per square inch. The temperature of the preservative during the pressure period shall be not less than 130° F., nor more than 190° F., and shall average at least 150° F. After the cylinder is emptied of preserving solution, a vacuum shall be maintained until the material can be removed from the cylinder free of dripping preservative.

At least once each day the railroad's representative shall determine penetration by analysis. Either the "iodine-potassium ferricyanide-starch" or the "potassium-ferrocyanide-uranium-acetate" color reaction test to determine the penetration by its visibility will generally be satisfactory.

From ties samples shall be taken at middle and rail sections; from other material samples shall be taken as desired. Any holes that may be bored shall be filled with tight-fitting treated plugs.

The treating plant shall be equipped with the thermometers and gauges necessary to indicate and record accurately the conditions at all stages during the treatment, and all equipment shall be maintained in condition satisfactory to the railroad. The owner of the treating plant shall also provide and keep in condition for use at all times the apparatus and chemicals necessary for making the analyses and tests required in this specification.

Approved:
W. T. Tyler,
Director of Operations.

Approved:
H. B. Spencer,
Director of Purchases.

Washington, January 1, 1919.

UNITED STATES RAILROAD ADMINISTRATION.
DIRECTOR GENERAL OF RAILROADS.

SPECIFICATION FOR THE PRESERVATIVE TREATMENT OF WOOD WITH CREOSOTE OIL.

(Full-cell Process.)

Except when ordered otherwise by the railroad's representative, the material to be treated shall be air-seasoned until in his judgment any moisture in it will not prevent injection of the specified amount of preservative; shall be restricted in any charge to woods into which approximately equal quantities of preserving fluid can be injected; and shall consist of pieces approximately equal in size and sapwood content, on which all framing, boring or adzing shall have been done, so separated as to insure contact of steam and preservative with all surfaces.

The preservative used shall be the one most suitable and available of the following standards of the American Wood-Preservers' Association:

"Creosote Oil, Grade 1, for Ties and Structural Timber."
"Creosote Oil, Grade 2, for Ties and Structural Timber."
"Creosote-Coal-Tar Solution for Ties and Structural Timber."
"Creosote Oil, Grade 3, for Ties and Structural Timber."

The material shall retain the amount of creosote oil necessary to permeate all of the sapwood and as much of the heartwood as practicable. The quantities specified may vary from 10 pounds per cubic foot for material from needleleaved trees from which most of the sapwood has been removed to 24 pounds per cubic foot for piling which has wide sapwood. The quantity of creosote oil retained shall be calculated, on the basis of 100° F., from readings of working-tank gauges or scales or from weights of at least one-tenth of the material on a suitable track scale before and after treatment, checked as may be desired by the railroad's representative.

After the material is placed in the cylinder, a vacuum of at least 22 inches shall be maintained until the wood is as dry and as free of air as practicable. The creosote oil shall then be introduced, without breaking the vacuum, until the cylinder is filled. The pressure shall be gradually raised, and maintained at a minimum of 125 pounds per square inch until the required quantity of preservative is injected into the material or until the railroad's representative is satisfied that the largest volumetric injection that is practicable has been obtained. The temperature of the preservative during the pressure period shall be not less than 170° F., nor more than 200° F., and shall average at least 180° F. After pressure is completed and the cylinder emptied of preservative, a vacuum shall be maintained until the material can be removed from the cylinder free of dripping preservative.

At least once each day the railroad's representative shall determine penetration by sampling ties at middle and rail sections; from other material

samples shall be taken as desired. Any holes that may be bored shall be filled with tight-fitting creosoted plugs.

The treating plant shall be equipped with the thermometers and gauges necessary to indicate and record accurately the conditions at all stages during the treatment, and all equipment shall be maintained in condition satisfactory to the railroad. The owner of the treating plant shall also provide and keep in condition for use at all times the apparatus and chemicals necessary for making the analyses and tests required in this specification.

When permission is given to prepare material for treatment by steaming instead of seasoning by air, it shall not be subjected to pressures or temperatures for periods sufficient to injure the wood.

Approved:
W. T. Tyler,
Director of Operations.

Approved:
H. B. Spencer,
Director of Purchases.

Washington, January 1, 1919.

United States Railroad Administration.
director general of railroads.

SPECIFICATION FOR THE PRESERVATIVE TREATMENT OF WOOD WITH CREOSOTE OIL.

(Empty-cell Process with Initial Air Pressure and Final Vacuum.)

Except when ordered otherwise by the railroad's representative, the material to be treated shall be air-seasoned until in his judgment any moisture in it will not prevent injection of an adequate amount of preservative; shall be restricted in any charge to woods into which approximately equal quantities of preserving fluid can be injected; and shall consist of pieces approximately equal in size and sapwood content, on which all framing, boring, or adzing shall have been done, so separated as to insure contact of air and preservative with all surfaces.

The preservative used shall be the one most suitable and available of the following standards of the American Wood-Preservers' Association:

"Creosote Oil, Grade 1, for Ties and Structural Timber."
"Creosote Oil, Grade 2, for Ties and Structural Timber."
"Creosote-Coal-Tar Solution for Ties and Structural Timber."
"Creosote Oil, Grade 3, for Ties and Structural Timber."

The material shall retain an average of at least 5 pounds of creosote oil per cubic foot, which shall permeate all of the sapwood and as much of the heartwood as practicable, and no charge shall retain less than 90 per cent nor

more than 110 per cent of the quantity per cubic foot that may be specified. The amount of preservative retained shall be calculated, on the basis of 100° F., from readings of working-tank gauges or scales or from weights of at least one-tenth of the material on a suitable track scale before and after treatment, checked as may be desired by the railroad's representative.

After the material is placed in the cylinder it shall be subjected to air pressure of sufficient intensity and duration to provide under a vacuum the ejection of preservative necessary to insure the required retention. For example: With red oak pressures of 40 to 60 pounds for 30 minutes, while with pine having a large percentage of sapwood pressures of 70 to 90 pounds for 30 minutes will be required. The preservative shall then be introduced, the air pressure being maintained constant until the cylinder is filled. The pressure shall be gradually raised to at least 150 pounds per square inch, and maintained until all of the sapwood and as much of the heartwood as practicable are saturated, or until the railroad's representative is satisfied that the largest volumetric injection that is practicable has been obtained. The temperature of the preservative during the pressure period shall be not less than 170° F., nor more than 200° F., and shall average at least 180° F. After the pressure is completed the cylinder shall be speedily emptied of preservative and a vacuum of at least 22 inches be promptly created, and maintained until the material can be removed from the cylinder free of dripping preservative.

At least once each day the railroad's representative shall determine penetration by sampling ties at middle and rail sections; from other material samples shall be taken as desired. Any holes that may be bored shall be filled with tight-fitting creosoted plugs.

The treating plant shall be equipped with the thermometers and gauges necessary to indicate and record accurately the conditions at all stages during the treatment, and all equipment shall be maintained in condition satisfactory to the railroad. The owner of the treating plant shall also provide and keep in condition for use at all times the apparatus and chemicals necessary for making the analyses and tests required in this specification.

Approved:
W. T. Tyler,
Director of Operations.

Approved:
H. B. Spencer,
Director of Purchases.

Washington, January, 1919.

UNITED STATES RAILROAD ADMINISTRATION.
DIRECTOR GENERAL OF RAILROADS.

SPECIFICATION FOR THE PRESERVATIVE TREATMENT OF WOOD WITH ZINC CHLORIDE AND CREOSOTE OIL.

Except when ordered otherwise by the railroad's representative, the material to be treated shall be air-seasoned until in his judgment any moisture in it will not prevent injection of the specified amount of preservative; shall be restricted in any charge to woods into which approximately equal quantities of preserving fluid can be injected; and shall consist of pieces approximately equal in size and sapwood content, on which all framing, boring, or adzing shall have been done, so separated as to insure contact of steam and preservative with all surfaces.

The zinc chloride used shall be acid-free and shall not contain more than 0.1 per cent iron. Dry zinc chloride shall contain at least 94 per cent soluble zinc chloride, and in any solution purchased the percentage of zinc chloride specified shall be the quantity of zinc chloride required.

The creosote oil shall meet the standard of the American Wood-Preservers' Association for "Creosote Oil, Grade 3, for Ties and Structural Timber," amended as follows:

(3) The specific gravity of the oil at 38° C. compared with water at 15.5° C. shall be not less than 1.03 nor more than 1.07.

The material shall retain an average of 0.5 pound of dry zinc chloride and 3 pounds of creosote oil per cubic foot, which shall permeate all of the sapwood and as much of the heartwood as practicable, and no charge shall retain less than 90 per cent nor more than 110 per cent of these quantities per cubic foot.

The preserving mixture shall be composed of the volumetric proportions of creosote oil and of zinc-chloride solution of the necessary strength which are required to obtain the specified retention of the preservatives with the largest volumetric injection that is practicable, and shall be agitated in the working tank and cylinder so as to insure thorough mixing before and while the cylinder is being filled with preservative and while the preservative is being injected into the material. The strength of the zinc-chloride solution shall not exceed 5 per cent and shall be determined by analysis. Chemical titration, using a silver-nitrate solution with potassium-chromate indicator, before the zinc-chloride solution is mixed with the creosote oil will usually be satisfactory.

For example: With red oak the proportions shall be not less than 77 per cent of 5 per cent zinc-chloride solution and not more than 23 per cent of creosote oil, and the volume injected shall be not less than 20 per cent, while with pine having a large percentage of sapwood they shall be not less than

88 per cent of 2.5 per cent zinc-chloride solution and not more than 12 per cent of creosote oil, and the volume injected shall be not less than 40 per cent. The quantities of preservatives retained shall be calculated from readings of working-tank gauges or scales and from weights of at least one-tenth of the material on a suitable track scale before and after treatment, checked as may be desired by the railroad's representative.

Air-seasoned material shall be steamed in the cylinder for not less than one hour nor more than two hours, at a pressure of not more than 20 pounds per square inch, the cylinder being provided with vents to relieve it of stagnant air and insure proper circulation of the steam and being drained to prevent condensate from accumulating in sufficient quantity to reach the material. After steaming is completed, a vacuum of at least 22 inches shall be maintained until the wood is as dry and as free from air as practicable. Before the preservative is introduced the cylinder shall be drained of condensate, and if the vacuum is broken a second one as high as the first shall be created. The preserving mixture shall be introduced without breaking the vacuum until the cylinder is filled. The pressure shall be gradually raised, and maintained at a minimum of 125 pounds per square inch until the required amount of preservatives is injected into the material, or until less than 5 per cent of the total quantity required has been injected during the latter half of one hour throughout which the rate of injection has persistently decreased, while the pressure has been held continuously at 165 or more pounds per square inch. The temperature of the preservative during the pressure period shall be not less than 170° F., nor more than 200° F., and shall average at least 180° F. After the cylinder is emptied of preserving mixture, a vacuum shall be maintained until the material can be removed from the cylinder free of dripping preservative.

At least once each day the railroad's representative shall determine penetration by analysis. With woods on which potassium ferro-cyanide and uranium acetate will produce color reaction, the penetration may be determined by its visibility. From ties, samples shall be taken at middle and rail sections; from other material samples shall be taken as desired. Any holes that may be bored shall be filled with tight-fitting creosoted plugs.

The treating plant shall be equipped with the thermometers and gauges necessary to indicate and record accurately the conditions at all stages during the treatment, and all equipment shall be maintained in condition satisfactory to the railroad. The owner of the treating plant shall also provide and keep in condition for use at all times the apparatus and chemicals necessary for making the analyses and tests required in this specification.

When water-gas-tar solution instead of creosote oil is used, the oil shall be a water-gas-tar product, of which at least 60 per cent shall be a distillate of water-gas tar and the remainder refined or filtered water-gas tar. It shall meet the following requirements:

(1) It shall not contain more than 3 per cent water.

(2) It shall not contain more than 2 per cent of matter insoluble in benzol.

(3) The specific gravity of the oil at 38° compared with water at 15.5° C. shall not be less than 1.03 nor more than 1.07.

(4) The distillate, based on water-free oil, shall be within the following limits:

Up to 210° C., not more than 8 per cent.
Up to 235° C., not more than 20 per cent.
Up to 355° C., not less than 60 per cent.

(5) The specific gravity of the fraction between 235° C. and 315° C. shall not be less than 0.98 nor more than 1.02 at 38° /15.5° C.

(6) The residue above 355° C., if it exceeds 5 per cent, shall have a float test of not more than 50 seconds at 70° C.

(7) The oil shall not yield more than 10 per cent coke residue.

(8) The foregoing tests shall be made in accordance with the standard methods of the American Railway Engineering Association and the American Wood-Preservers' Association.

When a distillate of water-gas tar instead of creosote oil is used, it shall meet the following requirements:

(1) It shall not contain more than 3 per cent water.

(2) It shall not contain more than 0.5 per cent of matter insoluble in benzol.

(3) The specific gravity of the oil at 38° compared with water at 15.5° C. shall not be less than 1.02.

(4) The distillate, based on water-free oil, shall be within the following limits:

Up to 210° C., not more than 5 per cent.
Up to 235° C., not more than 25 per cent.
Up to 355° C., not less than 80 per cent.

(5) The specific gravity of the fraction between 235° C. and 315° C. shall not be less than 0.98 nor more than 1.02 at 38° /15.5° C.

(6) The residue above 355° C., if it exceeds 5 per cent, shall have a float test of not more than 50 seconds at 70° C.

(7) The oil shall not yield more than 2 per cent coke residue.

(8) The foregoing tests shall be made in accordance with the standard methods of the American Railway Engineering Association and the American Wood-Preservers' Association.

Approved:
W. T. Tyler,
Director of Operation.

Approved:
H. B. Spencer,
Director of Purchases.

Washington, January 1, 1919.
(Revised January 1, 1920.)

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DOUGLAS FIR AS A STRUCTURAL TIMBER.

C. J. HOGUE.*

(Presented February 18, 1920.)

DOUGLAS FIR at present constitutes about twenty per cent. of the lumber production of the United States. An increasing knowledge and presentation of its properties, however, is causing a rapidly growing demand for it in markets far distant from the source of supply, and the production will increase annually for many years to come. Many alarmist statements are being made to the effect that our national timber resources will soon be exhausted; a reassuring note, however, may be found in the fact that the Douglas fir forests are at present growing faster than they are being reduced, and their natural reproduction is so prolific that with the growing interest in a national forest policy, adequate fire protection and a logical and economically sound recognition and solution of the burden of interest and taxation involved in re-forestation, there is every reason to believe that the West Coast forests cannot only take up the slack in other producing regions until they can be re-forested and again come into the market, but that the amount of standing timber in Douglas fir need never be less than it is to-day.

New England does not seem in the past to have received Douglas fir of representative quality. This is probably due to

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the fact that there has been no direct connection between the market and the manufacturer and that until recently criterions have not been available for the selection of timbers with particular relation to strength properties. Douglas fir is of medium weight, which means ease in handling; but has remarkable strength properties, and when compared in equivalent qualities is equal in strength properties to any commercial structural timber, and is superior to most.

The Nature of Wood.

The element of wood structure is the fiber, — a long, slender, hollow cell closed at both ends, communication through the walls of which is by means of microscopic apertures or "pits" in adjacent cell walls. Assembled in wood structure and magnified 50 to 250 times, depending on the species, the arrangement of cells looks very much like the ordinary honeycomb. (See Figs. 1 and 2.)

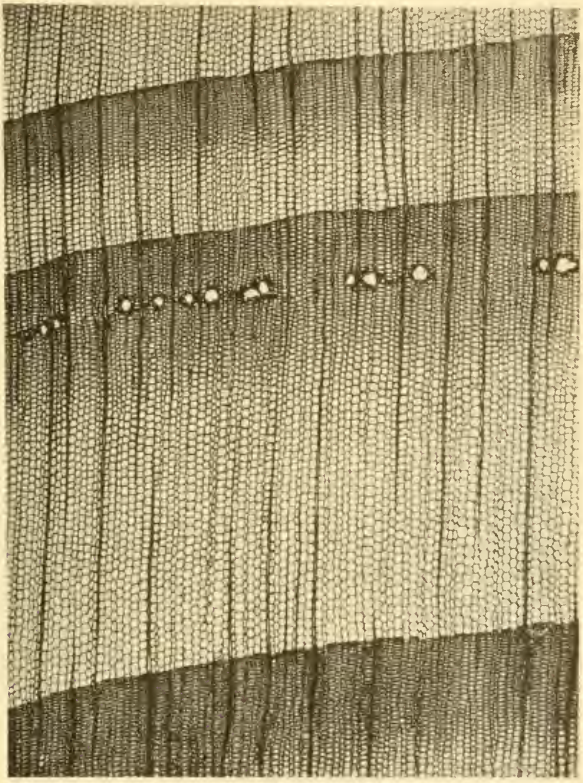
The cellular structure of softwoods is simple, and the cells are largely uniform in size and arrangement; the structure of hardwoods, on the other hand, is complex and is composed of several types of cells and fibers, which vary materially in size, and twist and intertwine to give the toughness and resistance to splitting which are characteristic of that class of wood.

Wood substance, or the material of the cell walls, consists of a skeleton or framework of cellulose, impregnated and filled in with lignin. Both are carbohydrates, of different chemical formulæ but composed of the same elements as sugar and starch. Wood substance is colorless, odorless and tasteless, these properties being added by infiltrated and deposited gums, oils and minerals.

The specific gravity of all wood substance, whether hardwood or soft, light or heavy, varies only slightly from 1.55. The weight, buoyancy and porosity of woods, therefore, are dependent on the amount of wood substance they contain or the relation between the thicknesses of the cell walls and the air spaces or "lumens" within the cells.

The smallest grouping of the cells which can be seen without a microscope, except the pores of hardwoods and, occasionally,

resin ducts in softwoods, is their arrangement in the annual growth rings. In the early or spring growth of most woods the cell walls are thin and the cells are approximately square. In



Courtesy of Forest Products Laboratory, U. S. Forest Service, Madison, Wis.

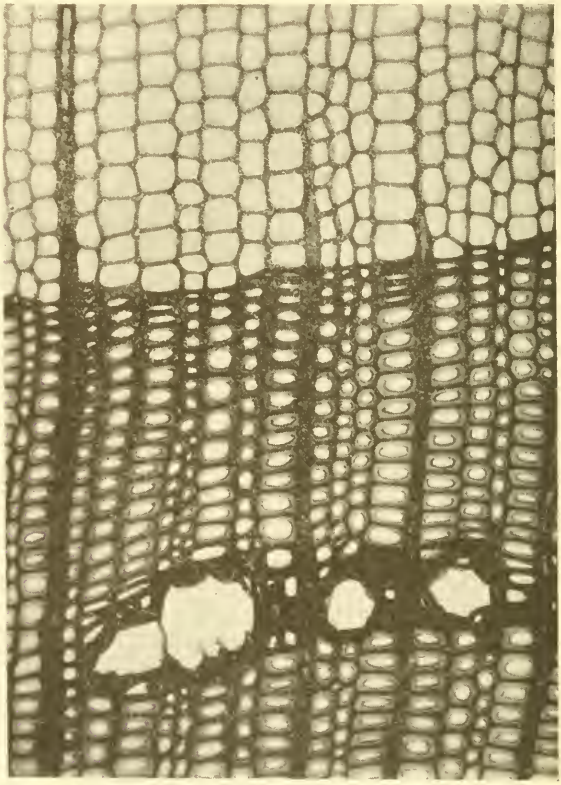
FIG. 1. — CROSS SECTIONS OF DOUGLAS FIR.

Showing cell structure. Thin-walled cells are spring wood; thick-walled cells are summer wood. Large openings are resin ducts.

Section through parts of four annual rings, two of which are complete. From photomicrograph magnifying 50 diameters.

the late or summer growth the cell walls tend to be very much thicker, and the radial dimensions to be less than the circumferential or tangential dimensions; this may be due to tension

in the bark which restrains the growth radially. The reason for the difference in the amount of wood substance in the spring and summer growth is not fully known; one theory is that



Courtesy of Forest Products Laboratory, U. S. Forest Service, Madison, Wis.

FIG. 2. — CROSS SECTIONS OF DOUGLAS FIR.

Showing cell structure. Thin-walled cells are spring wood; thick-walled cells are summer wood. Large openings are resin ducts.

Section through parts of two annual rings. From photomicrograph magnifying 250 diameters.

with the completion of new shoot and leaf growth there is more plant food available for wood production. In some species the transition from spring wood to summer wood is

gradual; in others it is abrupt; but there is usually a decided contrast in color, the summer wood being harder and darker because of the greater amount of wood substance present.

The number of annual rings in the cross section of any tree or branch is a measure of its age, as a tree is completely enveloped each year, trunk, limbs and branches, by the year's growth and, on cutting a tree, the age at which it reached any height can be computed by deducting the number of annual rings at that height from the number at the base.

The second noticeable characteristic in a cross section of a tree or limb is the division of the annual rings into sapwood and heartwood. The sapwood is that next to the bark, and the heartwood that around the center of the tree. The relative proportion of sapwood and heartwood varies in different genera and in different species, and the cause of change from sapwood to heartwood is not known; rings which are sapwood in one part of a tree may be heartwood in another.

The function of sapwood is to serve as a vehicle for the transmission of moisture from the earth to the buds and leaves, where it is transformed into sap or plant food which then descends between the bark and the wood through what is known as the "cambium layer" to give nourishment to the new cells being formed, wood cells on the inside and bark cells on the outside. True sap seldom gets far from the cambium layer.

The heartwood is no longer concerned with the vital processes of the tree, but serves in mechanical support of the weight of the crown.

Factors which Influence Structural Timbers.

Factors which influence structural timbers are common to all species. A brief discussion of them may be of value, therefore, before considering the limiting factors for Douglas fir.

Locality of growth has some influence on the strength of timber, but its influence is usually overestimated in that there may be as much difference between stands of timber in one region as in widely separated regions. Douglas fir is the one species in which silviculturists recognize two localities of growth — the Pacific Coast region and that of the Rocky Mountains,

the Douglas fir of the Pacific Coast growing under more favorable conditions and therefore developing better qualities.

Atmospheric temperature has little effect on wood, the coefficient of expansion of which is about the same as that of steel and concrete; expansion and contraction, which are factors in the use of wood, are the result of absorption and evaporation of moisture. Moisture content has a decided effect on the strength of wood, strength increasing 50 to 100 per cent. as wood becomes thoroughly dry. This increase in strength is largely offset in large timbers, however, by defects developed in seasoning so that it is unwise to base working stresses on values materially higher than those developed in green timbers. Moisture is contained in wood in the composition of wood substance, by absorption in the cell walls and as free moisture within the cells, and when green there may be a moisture content by weight of as much as or more than the wood substance itself. Drying takes place by the transfusion of moisture to the surface and evaporation there. The free water within the cells passes to the surface first, and there is no reduction in the moisture content of the cell walls until all the free water has been evaporated; when this has taken place and the cell walls are still completely saturated, the "fiber saturation point" is said to have been reached; this is at a moisture content of 20 to 30 per cent. of the weight of the wood substance. Below this point wood is air dried to between 10 and 15 per cent. and kiln dried to 5 or 6 per cent.

Shrinkage does not take place until the moisture falls below the fiber saturation point and the cell walls begin to give up their moisture. Exposed to moisture, wood again absorbs it and expands at about the same rate as that at which it shrank.

Checking in shrinking is due to two causes: a lack of uniformity in the rate of shrinkage throughout the piece and the greater shrinkage of wood circumferentially than radially. The first can be overcome by care in drying; the second is a natural property and allowance must be made for it in pieces of timber size.

Heartwood and sapwood have been determined to be equal in strength properties, but sapwood is less durable when exposed to decay-producing conditions.

Rate of growth is not in itself a definite factor of strength, although softwoods of exceptionally fast or slow growth are usually below the average in strength; hardwoods, on the other hand, are usually of the greatest strength if of rapid, and at the same time dense, growth.

Density as indicated by specific gravity is a close measure of strength. Wood substance is quite uniform in strength, as well as being almost uniform in weight, so that the relative strengths of woods are closely proportional to their weights or the amounts of wood substance they contain.

Specific gravity is somewhat of a laboratory determination, but in many species the proportion of summer wood, the dense, dark portion of the annual ring, furnishes a visual means of determining timbers which are of adequate strength, although sometimes rejecting others equally good.

One of the most dominating factors in the strength of a timber is the size and position of knots. As all normal limb growth starts at the pith and is intergrown with the trunk, knots will always be formed near the center of a tree. As lower limbs die and break off, however, the short projecting portion will first be encased, but not intergrown, and later growth will entirely encircle the remnant of the one-time limb, providing the long lengths of clear lumber available in trees of old growth. The effect of a knot is, of course, largely proportional to its size; it is undesirable to have a rotten knot or one which will drop out; and the location of a knot is a material factor in its effect. The amount and character of stress applied to a knot are large factors in its effect; a knot, while usually harder than the surrounding wood and therefore stronger in compression across the grain, still has in this property only a fraction of the strength of the surrounding wood in compression along the grain. When a knot and the surrounding wood are both in compression across the grain, the knot is not necessarily a source of weakness; when a knot is in a portion of a beam in which the dominant stress is shear, it may be a factor in greater resistance; where it destroys the continuity of surrounding fibers in tension or compression it is a source of weakness.

Shakes and checks are factors of weakness in resistance to shear.

Angle of grain is of two kinds, and both are of importance. Diagonal grain is caused by a log not being cut parallel to the annual growth rings; it can be prevented by care in sawing. Spiral grain is a natural defect due to the fibers in the annual ring departing somewhat from the vertical as if the circle of the annual ring had been twisted slightly about the center of the tree as an axis; this defect is more insidious than diagonal grain because harder to detect, as it may be present in a piece in which the grain as shown by the annual rings is parallel to the edges of the timber on four sides.

Results of tests are not comparable unless many of the above factors are observed and recorded. Tests on small specimens of clear wood must be made on pieces of equal moisture content and specific gravity or the results must be corrected according to known laws for variation in these properties. Additional variable results will obtain in large specimens, depending on the presence or absence of knots, shakes and checks and diagonal and spiral grain.

Application of Structural Factors to Douglas Fir.

Recognizing the properties and defects which are factors in the strength of timbers it is then a question of setting certain standards which will assure a satisfactory minimum strength and at the same time secure material in sufficient quantity. The principal factors necessary for such selection are: density, rate of growth, size and position of knots, amount of shake and angle of grain.

In applying these factors to Douglas fir it has been found that a specific gravity slightly above .4 will assure adequate strength in clear wood to justify a working stress of 1 600 lbs. per square inch in the extreme fiber in bending, and would be obtained in material having a density visually determined by one third or more summer wood, although some pieces with less than one third summer wood would have adequate strength.

Rate of growth is fixed at not less than six rings per inch unless one half the annual ring is summer wood, and the grain must not be so fine that the percentage of summer wood is not easily discernible.

Knots in beams where a fiber stress of 1 600 lbs. is to be used are limited to 1½ ins. in size in portions subjected to the greatest stresses, while with 1 300 lbs., knots may be 3 ins. if the timber has one third summer wood, otherwise they are limited to 1½ ins. In posts, with a fiber stress of 1 200 lbs., knots are limited to 3 ins., and with 1 000 lbs, to 4 ins. if the wood is of the required density, or 3 ins. if it is not.

Shakes are limited to one fourth the least dimension of the piece, and any combination of shakes and checks to the limit for shakes.

Angle of grain is limited to a slope of 1 in 20 in the center portion of beams, and to 1 in 15 in posts.

Density and structural rules for Douglas fir have recently been adopted by the West Coast Lumbermen's Association, representing over 90 per cent. of the production of Douglas fir. The application of the rules is guaranteed by inspection by the Pacific Lumber Inspection Bureau and by branding.

So many factors enter into the selection of timbers for structural purposes, and their utility is so greatly affected by the relative effect of natural properties and various defects that rigid rules, no matter how carefully prepared, are at best inadequate. The governing principles should be understood, and the rules applied with judgment. They contain minimum requirements and maximum defects, all of which may be present at one time; when the properties and defects of a particular timber vary slightly from the provisions of the rules, however, the relative effect on its strength should be considered in accepting or rejecting it.

Douglas Fir, the Species.

Douglas fir is a genus in itself (*Pseudotsuga*), distinct from the true firs (*Abies*), and there is only one commercial species (*Pseudotsuga taxifolia*). There are several types, however, which are more or less localized within the regions of growth.

Trees starting their growth in scattered stands are usually of the " red fir " type; they incline to be rather coarse in grain, light in weight and reddish in color. As the growth develops and the tops intertwine and the sunlight is shut out, the rate

of growth becomes increasingly slower and the wood more dense; this is known as the " bastard " stage of growth. After reaching an age of several hundred years the trees become so large and the rate of growth so slow that the wood again becomes low in density; this final stage is known as " old-growth, yellow fir."

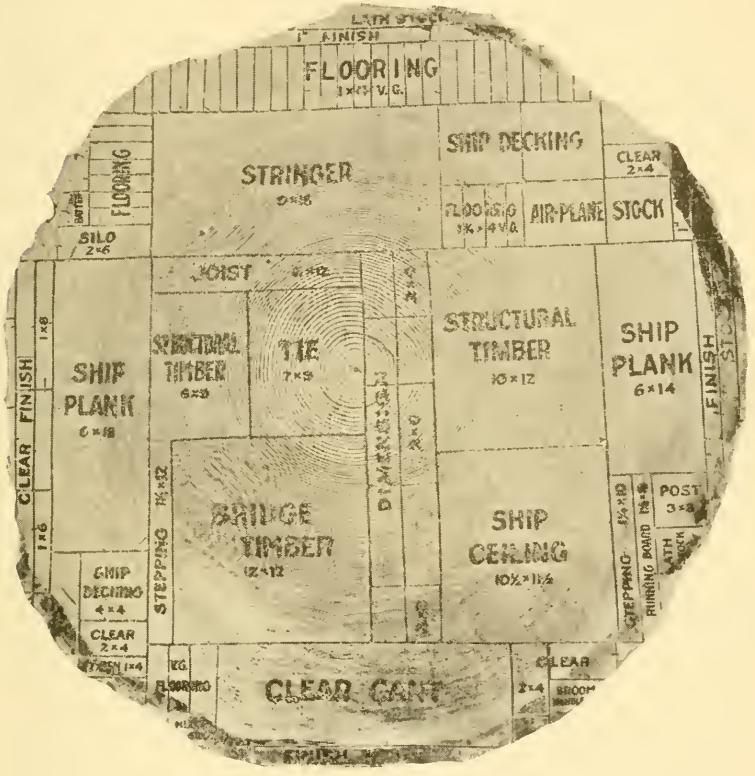
Trees germinating in close stands have a fairly fine grain, yellow color and high density from the start; due to the thickness of their growth, they become very tall and straight, reaching for the light and sun, and this type is known as " young, yellow fir." Some stands of timber are cut while in the red fir stage, and there are types intermediate between young red fir and young yellow fir, sometimes called bastard fir throughout their growth because they are similar to the bastard stage of the large old-growth trees.

The finest finish, siding, etc., comes from the old-growth yellow fir; coarse-grained young growth is cut into the common grades, and structural timbers from young or intermediate growth: young yellow fir; red fir, if not too coarse and light; and bastard fir, either from the bastard type or the bastard stage of the old-growth trees. Spars, masts and flagpoles of young yellow fir are in demand the world over, and are frequently known as of " Oregon pine." Fig. 3 shows the location of various grades and kinds of timber in a typical log.

Douglas fir has been at a handicap in comparison with pine, in that, in that genus, species names have largely come to have quality, rather than botanical, meaning. There are some 35 recognized species of pine, of which 15 are of commercial importance. Of the half dozen odd species of southern pine, those of principal structural importance, although each has the range in character and strength which is typical of any species, the commercial market has largely come to accept timbers of close grain and high density as " longleaf," whether actually of that species or not, pieces of close grain and light weight as " shortleaf," and pieces of coarse grain and light weight as " loblolly."

It was in recognition of the fact that the species did not matter if density were present, that the " density " grading rule

for southern pine was first proposed. The market, however, having previously begun to identify quality under species names, largely accepted the density grading rule as defining what it had begun to know as "commercial longleaf," and continued to a great extent to use this term.



Courtesy of West Coast Lumbermen's Association. All rights reserved.

FIG. 3.—THE DOUGLAS FIR "INDEX" LOG.

Showing location of various grades and kinds of timber in a typical log, and narrow ring of sapwood.

There being no such available species names to be applied to Douglas fir, it became necessary to adopt a density grading rule which would identify the growth of Douglas fir which gives

comparable values with "commercial longleaf" or "dense" southern pine.

Douglas fir is a remarkably strong wood for its weight; its strength, in terms of specific gravity, being materially greater than the average of American woods. This makes it a material of much greater strength than woods of its own weight and equal in strength to much heavier woods.

The West Coast believes it is offering to the Eastern market a material, not in competition with something else equally good and equally abundant in supply but one the equal of any it has ever had and the superior of many, and at a time when material comparable in quality is becoming increasingly difficult to obtain.

With the lightness of the spruce and the strength of the pine, with a mutual understanding on the part of the manufacturer of the needs of the market, and on the part of the purchaser of the properties and characteristics of the material available, and with a guide for selection which will identify and secure the character of material desirable, it is believed that the New England market will find great satisfaction in the introduction of West Coast woods.

Vol. VII MAY, 1920 No. 5

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PROCEEDINGS

ERRATA

April Journal

The words "Perforated" and "Not perforated," Fig. 1, Fig. 2 and Fig. 3,—Blake's paper,—should be interchanged.

Society of Civil Engineers was held this evening at Chipman Hall, Tremont Temple, and was called to order at eight o'clock by the President, Frank A. Barbour.

There were 78 members and visitors present.

The record of the annual meeting of March 17 was read and approved.

The Secretary reported for the Board of Government the election of the following candidates to membership in the Society in the grades named:

Members — Messrs. Albert W. Badger, George S. Coleman, John E. Connor, Richard H. Ellis, Charles E. K. Fraser, George F. Haskell, William V. P. Hoar, Frank O. Holmes, Daniel J. Lynch, Walter A. Maloy, J. Wendell Moulton, Daniel A. Murphy, Clarence G. Norris, Edwin S. Parker, Herbert L.

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PAPERS IN THIS NUMBER.

Address at the Annual Meeting. Leonard Metcalf.

Discussion of Small Sewage Pumping Stations. Thorndike Saville.

Memoir of Deceased Member.

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Contributors are hereby notified that proof will not be submitted to them for examination unless requested before the 10th of the month preceding the month of publication.

MINUTES OF MEETINGS.

BOSTON, April 21, 1920. — A regular meeting of the Boston Society of Civil Engineers was held this evening at Chipman Hall, Tremont Temple, and was called to order at eight o'clock by the President, Frank A. Barbour.

There were 78 members and visitors present.

The record of the annual meeting of March 17 was read and approved.

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Paterson, Waldo F. Pike, Mark E. Pitman, Henry A. Sherman, Edward L. Walker and Ernest M. Young.

Junior — Mr. Kenneth C. Reynolds.

The Secretary also announced the appointment by the Board of Government of the following committees of the Society:

On the Library — S. Everett Tinkham, chairman; Howard B. Luther and Edward H. Rockwell.

On Publication — Sturgis H. Thorndike, chairman; Harold K. Barrows and Henry B. Wood.

On Run-Off Available for Water-Power Purposes — Arthur T. Safford, chairman; H. S. Boardman, A. C. Eaton, X. H. Goodnough, R. A. Hale, C. H. Pierce, W. H. Sawyer, C. W. Sherman, W. F. Uhl, F. E. Winsor and D. M. Wood.

On Membership — Frank B. Walker, chairman; John B. Babcock, 3d; John E. L. Monaghan, Samuel P. Waldron and John P. Wentworth.

On Social Activities — Charles R. Berry, chairman; Armand W. Benoit, Harrison P. Eddy, Jr.; Ralph W. Horne, Waldo F. Pike and Howard C. Thomas.

On Papers and Program — Frank A. Barbour, chairman; Gordon M. Fair, Frank A. Marston, George E. Russell, George A. Sampson, Sanford E. Thompson, S. Everett Tinkham and Leonard C. Wason.

On Legislative Matters — Richard A. Hale, chairman; Charles B. Breed, Edwin H. Rogers, Hartley L. White, Frank O. Whitney.

On Welfare — Charles R. Gow, chairman; Charles R. Berry, Beardsley Lawrence, Frank A. McInnes, Leonard Metcalf, Reeves J. Newsom and John F. Osborn.

On Compensation of Engineers — Charles R. Gow, chairman; Frank A. Barbour, Henry F. Bryant, Walter W. Clifford, Luzerne S. Cowles, Charles E. Nichols, Barzillai A. Rich, Charles M. Spofford and John P. Wentworth.

The President, in a brief address, called attention to the appointment of a committee on membership which would, he hoped, enter upon a vigorous campaign and raise the total membership of the Society above the one-thousand mark. He asked for the earnest coöperation of the members in this work, and promised the committee the full support of the Board of Government.

The President announced that the board had, in answer to the petition of about twenty members, established a new

section of the Society, to be known as the "Designers' Section." A preliminary meeting has already been held, and at the next meeting, called for April 28, a code of by-laws would be adopted and officers elected as provided for in the By-Laws of the Society.

The Secretary presented a memoir of John S. Humphrey, a member of the Society, who died February 5, 1919, prepared by a committee consisting of Messrs. Charles B. Humphrey and Frank O. Whitney. The memoir was accepted and ordered printed in the JOURNAL.

Mr. John C. Chase suggested that the announcement of the death of Miss Evans, the Assistant Librarian of the Society, which appeared in the notice of this meeting, be made a part of its record, and it was so ordered by the President:

"Members of the Society, especially those who have used its rooms in recent years, will learn with sincere regret of the death of Miss Mary E. Evans, the efficient assistant to the Secretary and Assistant Librarian, which occurred April 8, 1920.

"Miss Evans has been in charge of the Society's Library for the past seven years, and during that time has re-arranged and re-catalogued the larger portion of it in a most satisfactory manner.

"By her pleasing personality, her helpfulness to all who had occasion to visit our rooms, and her unfailing courtesy at all times, she has left a gracious memory which will be long cherished by our members.

"The Secretary wishes to place on record his deep personal appreciation of the invaluable assistant she has been to him during all these years, and of the loyal and conscientious manner in which she performed her work."

The President then called on the speaker of the evening, Past-President James W. Rollins, to present his paper entitled, "Construction of Masonry Piers and abutments of the Thames River Bridge at New London, Conn." The paper was fully illustrated with lantern slides, and proved most interesting.

A brief discussion followed, by members of the Society and by Clarence Blakeslee, member of the American Society of Civil Engineers.

At 9.30 o'clock the meeting adjourned.

S. E. TINKHAM, *Secretary.*

BOSTON, May 19, 1920. — A regular meeting of the Boston Society of Civil Engineers was held this evening at Chipman Hall, Tremont Temple, and was called to order at 7.55 o'clock by the President, Frank A. Barbour.

There were 85 members and visitors present.

The record of the last meeting was read and approved.

The Secretary reported for the Board of Government the election of the following candidates to membership in the grade of member:

Messrs. Edward H. Cameron, George W. Dakin, Francis J. Gateley, William E. Hannan, William R. Holway, William A. Johnson, Arthur J. Lennon, George P. Longfellow, Lawrence J. Monahan and James P. O'Connell.

The President announced the death of Loammi F. Baldwin, a member of the Society, who died May 9, 1920. By vote the President was requested to appoint a committee to prepare a memoir of Mr. Baldwin.

The committee appointed consists of Messrs. Richard A. Hale and James R. Baldwin.

The Secretary, for Mr. John C. Chase, presented the report of the committee appointed to prepare a memoir of Frank L. Fuller, and by vote the report was accepted and ordered printed in the JOURNAL of the Society.

The President presented and read the report of the Committee on Compensation of Engineers, which is appended hereto.

After some discussion, on motion of Mr. Whitney it was voted —

That the report be received and the committee discharged, and that the recommendations in the report be submitted to the Society for a letter ballot.

The President stated that the Board of Government had received a letter from Mr. Charles W. Sherman suggesting that a committee of the Society be appointed to consider the advisability of petitioning the legislature at its next session for the passage of an engineers' license law in this state. Mr. Sherman said, further, that the state of New York had just passed such

a law, and this matter of licensing engineers seemed to be spreading rapidly over the country, and in order to enjoy the reciprocal relations which many of these laws provide, it would seem to be necessary, as a matter of self-defense, we should have similar licenses in Massachusetts. The President stated that the Board of Government recommended the appointment of such a committee. On motion of Professor Spofford, it was voted —

That the President be authorized to appoint a committee of five to consider the advisability of securing the passage of a law licensing engineers at the next session of the legislature, and if they deemed such a law desirable, to draft such a proposed law and submit it with their report.

The President has named as the committee Messrs. Charles W. Sherman, Charles T. Main, Irving E. Moultrop, Edwin H. Rogers.

It was voted to hold the next meeting of the Society on June 9, 1920, in connection with the joint outing of this Society and the New England Water Works Association.

By vote the President and Treasurer were authorized to execute a lease on behalf of the Society with the Tremont Temple Baptist Church, for the term of three years, and also to execute leases with the sub-tenants of the Society.

The President then introduced the speaker of the evening, Prof. George W. Pierce, of Harvard University, who addressed the Society most interestingly on the subject of "Submarine Detection and Acoustical Aids to Navigation." The address was illustrated with lantern slides.

At the conclusion of the address, Professor Pierce answered freely many questions of the members.

Before adjourning, a rising vote of thanks was tendered Professor Pierce.

Adjourned.

S. E. Tinkham, *Secretary.*

Report of Committee on Compensation of Engineers.

Boston, April 26, 1920.

To the President and Members of the
Boston Society of Civil Engineers:

On July 3, 1919, the Board of Government of the Boston Society of Civil Engineers, through its president, appointed a committee to investigate and report to the Board its conclusions respecting the subject of Compensation of Engineers. Under date of February 2, 1920, the committee submitted to the Board of Government an analysis of its investigations and conclusions, together with some suggestions of possible action by the Society. This report was submitted by the Board of Government to the membership for information and criticism, and was further discussed at a special meeting held February 25 at the Society's rooms.

As a result of this discussion it was voted that the matter be referred back to the committee for further consideration. In addition, the following motion was adopted:

"That this meeting commend to the favorable consideration of the Committee on Compensation of Engineers the suggestions that —

"(*a*) Government, state and municipal engineering service should command compensation measurably greater than the equivalent service rendered to other parties.

"(*b*) There should be a substantial vertical rise from the upper limit of one grade to the lower limit of the next higher grade.

"(*c*) An effort should be made to formulate and secure governmental, state and municipal adoption of a plan for the automatic increase in compensation, within each grade of service and between the limits fixed, said increase to be dependent upon and in a measure commensurate with the length of the term of service.

"(*d*) The schedule of salaries advocated by the Engineering Council is reasonable, just to employer and employee, and should be endorsed by the Society, and such endorsement I believe requires certain formalities.

"(*e*) In cases where the public authorities are unwilling to grant increases in compensation sufficient to provide salaries equal to the schedule of Engineering Council, this Society should approve an increase equivalent to about 40 per cent. in all grades of service — with the distinct understanding that such increase is to constitute simply a first step, and that further increase should be forthcoming from year to year as rapidly as possible until the schedule of Engineering Council shall have been put into effect."

In accordance with these instructions your committee has given further consideration to the question involved, and especially to the recommendations outlined in the above vote, and has reached the following conclusions:

(*a*) The committee does not feel warranted in recommending that government, state and municipal engineering service should command compensation measurably greater than equivalent service rendered to other parties. The committee is strongly of the opinion that engineering service is entitled to equal compensation whether publicly or privately rendered.

(*b*) In view of the action of the committee with respect to suggestion (*d*), which is discussed further on, no special action is required on this suggestion.

(*c*) While recognizing many of the practical difficulties which will be

encountered, the committee is of the opinion that there will be some merit in the adoption of a plan for the automatic increase in compensation within each grade of service, and commensurate also with the length of service. It seems to the members of the committee, however, that this is a matter which may well be referred to the permanent Committee on Welfare, for its future consideration.

(*d*) The committee feels that the schedule of salaries advocated by Engineering Council is reasonable, just to employer and employee, and that it should be endorsed by the Society. It is felt that any action looking to improvement in the compensation now paid to engineers can best be prosecuted when approached with a unanimity of opinion and purpose, and the committee therefore recommends that immediate steps be taken by the Society to endorse the proposed schedule of salaries already approved by Engineering Council.

(*e*) Regarding the suggestion that the Society approve an increase equivalent to 40% in all grades of public service as a possible first step toward the attainment of its final schedule, the committee is of the opinion that there is nothing to be gained by such action at this time. The various budgets having in general been prepared and approved for the ensuing year, it will not be possible to effect any changes in existing allowances. Without knowledge of the conditions which will prevail when the new budgets are in process of preparation for the next year's salaries, it is very difficult to formulate an intelligent policy with respect to action of this sort. If the present unsatisfactory conditions continue to obtain in the public service, it is possible that relief will come automatically through the inability of public departments to obtain satisfactory engineering service except at substantial advances in salaries. Furthermore, it seems to the committee to be unwise to establish a standard of salaries as already recommended and immediately thereafter repudiate the schedule by offering to adjust temporarily upon a lower basis. Your committee is of the opinion, therefore, that no action should be taken on this suggestion at the present time

Respectfully submitted,

(Signed) Frank A. Barbour.
Henry F. Bryant.
Walter W. Clifford.
Barzillai A. Rich.
Charles M. Spofford.
John P. Wentworth.
Charles R. Gow, *Chairman*.

APPLICATION FOR MEMBERSHIP.

[May 20, 1920.]

The By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communi-

cate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

Brown, Oliver Blanchfield, Watertown, Mass. (Age 19, b. Marblehead, Mass.) Educated in public school, graduate English High School, Boston, technical course, June, 1918. Draftsman with Stone & Webster, July, 1918, to Jan., 1919; draftsman Fay, Spofford & Thorndike from Feb., 1919, to present time. Refers to C. R. Berry, C. A. Farwell, F. H. Fay, R. W. Horne, E. D. Mortenson and W. F. Pike.

Brown, Walter Irving, Boston, Mass. (Age 50, b. East Boston.) Educated in the public schools and took engineering course at Y. M. C. A. Rodman, City of Boston, 1895 to 1900; transitman with Metropolitan Sewerage Commission, in charge of party in construction work 1901 and 1902; transitman, City of Boston, Sewer Dept., in charge of party on construction work, 1903 to 1917; chief inspector of equipment, Quartermaster's Dept., Boston Army Supply Base, 1917 and 1918, and at present transitman in Sewer Dept., Boston, in charge of party on construction work. Refers to J. E. Carty, E. S. Dorr, C. R. Gow, G. W. Hamilton and E. F. Murphy.

Bryant, George Leo, Boston, Mass. (Age 28, b. Boston, Mass.) With T. G. O'Connell, Boston, drafting and inspecting, Aug. 1914, to March, 1917; with E. B. Badger & Sons Co., drafting and inspecting, March, 1917, to Oct., 1918; with Peter Gray & Sons, Inc., as chief draftsman, Oct., 1918, to June, 1919; assistant plant engineer and draftsman, with Aberthaw Constr. Co., June, 1919, to date. Refers to J. A. Garrod, H. A. Gray, A. B. MacMillan, E. D. Mortenson and R E. Parker.

Burleigh, Willard Gile, Waverley, Mass. (Age 26, b. Malden, Mass.) Elected a Junior, Nov. 17, 1915. Oct , 1915, to April, 1916, installing and inspecting thermostatic heating control devices; April, 1916, to Sept., 1917, drafting and compiling cost data for valuation purposes; Sept., 1917, to Aug., 1919, non-commissioned officer, Corps of Engineers. In charge of grading and track-laying parties for U. S. A. railroad yards at St. Nazaire. Instructor on Dorel process reproduction and plane table survey at Army Staff College, Langres; asst. in charge of drafting, map mounting and lithography, G-2-c, Third Corps; instructor in topographical drawing and liaison officer with the Section Topographique des l'Armes at Langres, Aug., 1919, to May, 1920, rated as computer, recording on building inventory, estimating for fire losses

and valuation purposes, and compiling insurance schedule, and at present transitman for Jackson & Moreland, Boston, on development projects. Refers to E. P. Bliss, N. C. Burrill, M. M. Cannon, J. B. Mailey, D. N. Peaslee and F. C. Shepherd.

Clark, William Allen, Boston, Mass. (Age 25, b. Winthrop, Mass.) Graduate Mass. Inst. of Technology, 1917, sanitary engineering course. With Mass. State Dept. of Health, July to Oct., 1917; captain Corps of Engineers, U. S. Army, Nov., 1917, to Feb., 1920; and with Lockwood, Greene & Co., since March, 1920. Refers to A. P. Porter, Dwight Porter, C. M. Spofford and H. C. Thomas.

Cleverdon, Herbert Squires, Watertown, Mass. (Age 32, b. New York City.) Student in civil engineering course, New York University, 1905–06; graduate of Mass. Inst. of Technology with S.B. degree, 1910; asst. engineer with Shepley, Rutan & Coolidge, Boston, 1910–13; traveled with the American Inst. of Architects in Europe and Asia Minor in 1912; structural engineer, Turners Falls Power and Electric Co., on hydro-electric development, 1913–15; engineer for American Mutual Liability Insurance Co., 1915–17; 1st lieutenant Engineers, 104th Engineers, 1917–19, and since 1919 with Lockwood, Greene & Co., Boston. Refers to J. B. Babcock, 3d, J. E. Hanlon, G. F. Hobson, Dean Peabody and A. L. Shaw.

Crandall, James Stuart, Malden, Mass. (Age 29, b. Dartmouth, N. S.) Graduate University of Maine, in civil engineering, 1915. Entered the employ of the Crandall Engineering Co. as assistant engineer in office and field; for a short time with W. W. Wight, C.E., Wellesley, Mass.; with Crandall Engineering Co., assistant engineer, Jan., 1917; 2d lieutenant with the 25th, 29th and 74th Engineers, from May, 1917, to June, 1919, and since that time with the Crandall Engineering Co., consulting and contracting engineers on dry docks, East Boston, and now assistant to the president of their company. Refers to H. S. Boardman, R. W. Horne, J. P. Wentworth and C. W. Wood.

Cross, Ralph Upton, Worcester, Mass. (Age 28, b. Worcester, Mass.) Graduate Tufts College, in civil engineering, 1916; assistant to general manager, E. J. Cross Co., Worcester, general contractors, 1916–17; enlisted June, 1917, commissioned 2d lieutenant, Q.M.C., May 30, 1918, and assigned to construction division of the army as inspector, July, 1918; promoted to 1st lieutenant, Aug., 1918, and discharged, Jan. 15, 1918. At present and since discharge, with E. J. Cross Co., of Worcester, general contractors, as vice-president. Refers to A. W. French, S. H. Pitcher, E. H. Rockwell, F. B. Sanborn and J. A. Tosi.

Eberhard, Walter Carl, Belmont, Mass. (Age 28, b. Boston.) Graduate Mass. Inst. of Technology, in civil engineering, 1914; was assistant in department of civil engineering at the Inst. of Technology from July, 1914, to July, 1916; from July, 1916, to Sept., 1917, draftsman in valuation corps, Rutland Railroad; Oct., 1917, to April, 1918, with Stone & Webster Engineering Corps, as chief of party on railroad location and construction, Picatinny Arsenal, Dover, N. J.; in naval reserve force from April, 1918, to Jan., 1919, first as

inspector of naval aircraft, and then commissioned ensign; and Feb., 1919, to the present time instructor in drawing and descriptive geometry at the Mass. Inst. of Technology. Refers to J. B. Babcock, 3d, C. B. Breed, G. L. Hosmer, J. W. Howard and A. G. Robbins.

Foster, Howard Leslie, Detroit, Mich. (Age 26, b. Merrimac, Mass.) From July to Sept., 1916, instructor in surveying at Mass. Inst. of Technology; Sept., 1916, to June, 1917, assistant in civil engineering at Inst. of Technology; June, 1917, to Feb., 1918, sales engineer with Witherow Steel Co., designing reinforced concrete structures and estimating steel; Feb. to Sept., 1918, instructor at U. S. A. School of Military Aëronautics at Inst. of Technology; Nov., 1918, to July, 1919, inspector and production manager with England Mfg. Co., Detroit, manufacturing shell punches; Aug., 1919, to April, 1920, structural engineer with Smith, Hinchman & Grylls, architects and engineers, Detroit, special designing and in charge of work, and April, 1920, to date, with Lockwood, Greene & Co., at Detroit office. Refers to C. B. Breed, G. L. Hosmer, L. J. Johnson and Dwight Porter.

Kinsman, Harold Leslie, Arlington, Mass. (Age 25, b. Cambridge, Mass.) Graduate Rindge Technical High School in 1915, and student in structural department of the Lowell Inst. of Industrial Foremen; Sept., 1916, to July, 1917, draftsman with Fay, Spofford & Thorndike; July, 1917, to April, 1919, with the 101st Engineers, U. S. Army; April, 1919, to date, draftsman with Fay, Spofford & Thorndike. Refers to C. R. Berry, R. W. Horne, E. D. Mortenson, W. F. Pike, B. A. Rich and K. C. Reynolds.

Morrill, George Pillsbury, Boston, Mass. (Age 46, b. Feeding Hills, Mass.) Member of American Society of Civil Engineers. Graduate civil engineering course at Yale University, 1897. From 1898 to 1901 rodman and transitman, city engineer's office, Springfield, Mass.; 1901 to 1909 in Philippine service as assistant engineer and second assistant city engineer of Manila, and resident engineer (1905–07) in charge of construction of masonry, dam, tunnels, pipe lines, roads, etc., for new Manila water works; 1907–14, in Cuba, designing and constructing water works, flood prevention works, roads, bridges, inspection, etc., for Cuba government; 1915, graduate work at Yale, and various small engagements including two months with Westinghouse, Church, Kerr Co., on construction of a powder factory for Ætna Explosive Co., at Drummondville, Quebec; Jan., 1916, to March, 1916, sales work; March, 1916, to Jan., 1920, supt. of construction with Raymond Concrete Pile Co., and Jan., 1920, to date, district manager of the Raymond Concrete Pile Co. Refers to Linton Hart, and is recommended by Messrs. Spofford, Thorndike and Tinkham of the Board of Government.

McSweeney, Thomas Francis, Framingham, Mass. (Age 27, b. Marlboro, Mass.) Graduate Mass. Inst. of Technology, 1916; foreman, Charles R. Gow Co., June to Sept., 1916; assistant superintendent Geo. A. Fuller Co., Sept., 1916, to March, 1917; with Fay, Spofford & Thorndike, March, 1917; construction manager, Concrete Steel Co., April, 1917, to March, 1918; engineer officer, U. S. A. T., March to Aug., 1918; structural engineer, U. S. S. B., E. F. C., concrete ship section, Aug., 1918, to Dec., 1919,

and since 1919, assistant engineer with the Turner Construction Co. Refers to C. R. Gow, E. F. Miller, Hugh Nawn, H. F. Sawtelle, C. M. Spofford and G. C. Whipple.

O'Brien, Martin J., Medford, Mass. (Age 26, b. Cambridge.) Graduate Lowell Industrial Foremen, M. I. T., 1915, and one year special course in reinforced concrete, 1916–17; with Lockwood, Greene & Co. from May, 1910, to present time, as draftsman and designer (steel and reinforced concrete), except eighteen months' service in the army, Oct., 1917, to May, 1919, as pilot, Air Service. Now with Lockwood, Greene & Co. Refers to L. B. Ellis, B. A. Rich, H. F. Sawtelle, P. W. Taylor and H. C. Thomas.

Scully, Francis Paul, Cambridge, Mass. (Age 26, b. Boston.) Graduate Mass. Inst. of Technology, 1915. Engaged in general contracting and building business, June, 1915, to Oct., 1917; lieutenant (j.g.) U. S. Navy, with Bureau of Steam Engineering, Div. of Aëronautics, Oct., 1917, to April, 1919; and from April, 1919, to date, secretary of The Scully Co., in engineering and construction work. Refers to W. F. Pike, G. E. Russell, H. C. Sheils, C. M. Spofford, H. C. Thomas and C. W. Wood.

Shaw, Edward Walter, Newtonville, Mass. (Age 29, b. Worcester, Mass.) Graduate Worcester High School, 1909, and at Worcester Polytechnic Institute, 1909–11; from 1911 to 1916 with C. W. Fisher, architect, L. W. Briggs Co., architects, and Central Building Co., general contractors; Jan., 1916, to June, 1918, with Eastern Bridge & Structural Co., as head of light iron drafting force; June, 1918, to March, 1919, with the Aberthaw Construction Co. as draftsman; March, 1919, to Aug., 1919, squad chief, and Sept., 1919, to date, specification writer. Refers to S. E. Coburn, H. A. Gray, A. B. MacMillan, E. D. Mortenson and R. E. Parker.

Theriault, William J., Cambridge, Mass. (Age 25, b. Meteghan, Digby Co., N. S.) Certificate from Wentworth Institute, 1920, architectural construction; general ship construction June, 1915, to Sept., 1917; with Nova Scotia Shipbuilding and Transportation Co., assistant superintendent of construction, Sept., 1917, to March, 1918; with Groton Iron Works, assistant superintendent of construction, March, 1918, to July, 1918; with Ship Construction and Trading Co., assistant master builder, July, 1918, to June, 1919, and since 1919 draftsman with the Aberthaw Construction Co. Refers to H. A. Gray, E. D. Mortenson, R. E. Parker and E. A. Varney.

Wood, Carl Wilbur, Winchester, Mass. (Age 29, b. Velasco, Tex.) Educated at Malden High School and Mass. Inst. of Technology, class of 1915; in 1917 employed by Mass. Harbor and Land Commission, as rodman on survey of Mass. and Conn. boundary line; 1908–12 with the War Dept., Harbor and Land Office, New London, Conn., as rodman and instrumentman; 1913, with Mass. Harbor and Land Commission, survey of Merrimack River; 1914, with Maine Highway Commission as engineer in charge of road construction for one section; 1915–17 with Metropolitan Water Works as assistant engineer on construction of water-supply mains, etc., and 1917 to date with Stone & Webster as follows: 1917–18, resident engineer on construction of the Watertown arsenal, Camp Kelly Aviation Field, Pittsfield

Power House; 1918–20, assistant engineer on railroad, yard and ship construction, Hog Island; and 1920 assistant engineer, construction division, Boston office of Stone & Webster. Refers to W. E. Foss, J. W. Howard, W. F. Pike, H. C. Thomas, D. M. Wood and H. B. Wood.

LIST OF MEMBERS.

ADDITIONS.

COLEMAN, GEORGE S. 15 Marmion St., Jamaica Plain, Mass.
ELLIS, RICHARD H. North Andover, Mass.
MALOY, WALTER A. 24 Duke St., Mattapan, Mass.
MOULTON, J. WENDELL, ... 23 Capitol St., Augusta, Me.
PARKER, EDWIN S. 117 Davis Ave., Brookline, Mass.
REYNOLDS, KENNETH C. 231 Morrison Ave., W. Somerville, Mass.
TURNER, HOWARD M. 70 State St., Boston, Mass.
WALKER, EDWARD L. 44 Union Ave., Framingham, Mass.
YOUNG, ERNEST M. 15 Oakland St., Brighton, Mass.

CHANGES OF ADDRESS.

ALLEN, C. S. 25 Duffield Road, Auburndale 66, Mass.
BABBITT, J. H. Engrg. Dept., The Miller Rubber Co., Akron, Ohio.
BIGELOW, W. W. c/o Lockwood, Greene & Co., 245 State St., Boston, Mass.
BROWN, W. M. 128 Market St., Room 510, Newark, N. J.
CARTER, H. H. 99 Chauncy St., Room 409, Boston, Mass.
COREY, K. T. 16 Ventura St., Springfield, Mass.
CUTTING, G. W., Jr. 50 Newton St., Auburndale 66, Mass.
DICKSON, A. D. 949 Washington St., Newtonville, Mass.
EWING, W. C., Campaign Director, American City Bureau, New York, N. Y.
FELTON, B. R 68 Waban Hill Rd. North, Chestnut Hill, Mass.
FOSTER, H. L. 122 Spokane Ave. W., Detroit, Mich.
GAGE, E. H. Care U. S. Public Health Service, Custom House, Norfolk, Va.
HART, LINTON 80 Boylston St., Boston 11, Mass.
HAYES, H. W. 163 State House, Boston 9, Mass.
KLINK, N. S. 314 Faneuil St., Brighton 35, Mass.
MCCONNELL, I. W. 125 East 46th St., New York, N. Y.
MORPHY, L. G. 56 Nottingham Rd., Brighton, Mass.
MORSE, C. F. P. O. Box 877, Southampton, N. Y.
REED, C. B. 1658 Holywood Road, Cleveland, Ohio
TUCKER, L. W., Care Dwight P. Robinson Co., 290 Arch St., Freeport, N. Y.
WEBB, D. C. Naval War College, Newport, R. I.
WOOD, H. B. 218 Commonwealth Pier, Boston, Mass.

DEATH.

BALDWIN, LOAMMI F. May 9, 1920.

PERSONAL NOTE.

Mr. Luis G. Morphy, of 56 Nottingham Road, Brighton, Mass., has resigned as principal assistant engineer of the Boston & Albany Railroad, to take a position with The Foundation Company of New York City as its representative in South America, and will terminate his services with the Boston & Albany on May 1. Mr. Morphy was born in Orizaba, Mexico, December 4, 1876, and came to America as a young man, graduating in 1900 from the Rensselaer Polytechnic Institute, at Troy, N. Y. Immediately after, he went into the employ of the New York Central Railroad at Albany, N. Y., in the engineering department. After serving in Buffalo, N. Y., and New York City, he came to Boston in October of 1907 as assistant engineer of maintenance of way and construction. He has been successively promoted to assistant to the chief engineer, designing engineer, division engineer and principal assistant engineer on the Boston & Albany. Mr. Morphy is a member of the American Railway Engineering Association, is president of the Boston Chapter of the American Association of Engineers, is a member of the Executive Committee of the New England Railroad Club, is a member of the Boston Society of Civil Engineers, the New York Railroad Club and other organizations.

He will sail on May 5 from New York City for Lima, Peru, and La Paz, Bolivia, and other important points in South America.

LIBRARY NOTES.

Recent Additions to the Library.

U. S. Government Reports.

Annual Report of the Interstate Commerce Commission for 1919.

Report of the Librarian of Congress for 1919.

Municipal Statistics for Cities for 1918.

Report of the International Boundary Commission for 1918.

Alaska Magnetic Tables and Magnetic Charts for 1920.

State Reports.

New York. Report of the State Engineer and Surveyor. Vols. 1 and 2, for 1918.

New Jersey. Annual Report of State Department of Health for 1919.

Connecticut. Annual Report of the Public Utilities Commission, 1919.

Rhode Island. Annual Report of the Public Utilities Commission, 1918.

Massachusetts. Annual Report of the Commission on Waterways and Public Lands, 1918.

Massachusetts. Annual Report of the Homestead Commission, 1918.

Municipal Reports.

Chelsea, Mass. Annual Report of the Water Commissioner for 1919.

Burlington, Vt. Annual Report of the Water Department for 1919.

Providence, R. I. Annual Report of the Water Supply Board, 1919.

New Bedford, Mass. Report of the Water Board for 1919.

Northampton, Mass. Annual Report of the Water Commissioners, 1919.

Newton, Mass. Annual Report of the Street Commissioner, 1919.

Wellesley, Mass. Annual Report of the Water and Municipal Light Commissioners, 1919.

Haverhill, Mass. Annual Report of the Board of Water Commissioners, 1919.

Cambridge, Mass. Annual Report of the City Engineer for 1918.

Dover, N. H. Annual Report of the Board of Water Commissioners for 1919.

Miscellaneous.

A New Method of Sewage Disposal. Sidney P. Armsby.

Test Data on Lime in Concrete and Mortar. Tyrrell B. Shertzer

Effect of Fineness of Cement. Duff A. Abrams.

Condensed Diagrams of the Inspection of the B. & A. R. R., 1897. P. H. Dudley.

LIBRARY COMMITTEE.

Vol. VII MAY, 1920 No. 5

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PAPERS AND DISCUSSIONS

This Society is not responsible for any statement made or opinion expressed in its publications

ADDRESS AT THE ANNUAL MEETING.

By Leonard Metcalf, President Boston Society of Civil Engineers

(March 17, 1920.)

Constructive Effort Versus Destructive Criticism and Inactivity in Professional Societies.

In laying down my duties as president of this fine old organization, I want to express to you the interest and pleasure which I have found in this office and my deep obligation to the Secretary and other members of the Board of Government and to many members of the Society, particularly the younger men, for their active support and assistance. I have felt keenly the responsibility of the position, as I have known personally many in the long line of competent engineers and administrators who have preceded me; but good team play and unity of purpose have made for very friendly relations on the Board and satisfaction in its work. So you will perhaps bear with me if I take the liberty of discussing with you briefly the problem of unrest in our engineering societies and of suggesting its solution through a revitalized conception of possible lines of service to their members.

General Unrest.

Never has there been greater need of open minds to review old traditions and principles, the soundness of which have been demonstrated by time, to promptly and intelligently readjust them to the rapidly changing conditions and to raise new

standards that shall command confidence and bring unity of purpose and action.

I am cognizant of the general spirit of unrest which exists all over the country, no less among engineers than others, for I have met it within the past two years from the East to the far West and from the North to the extreme South of this country. The grievances are real, for the present burdens are heavy and many injustices need to be righted, as you all know. They have crystallized, for example, in the reports of the development committees of many societies, in that of the Joint Conference Committee of the four National Engineering Founder Societies; in the work of Engineering Council and report of its Committee upon the Compensation of Engineers; in the well-considered report of our own Committee on Compensation of Engineers; in a number of admirable articles from the pen of that veteran editor, Mr. Charles Whiting Baker; in the formation of a rapidly growing new society, making welfare work for engineers its primary object, and even of labor unions composed of engineers affiliated with organized labor groups.

Engineers Unskilled Salesmen of Their Labor.

Engineers have not yet learned to fairly appraise their services and to sell them profitably. In the gigantic task of the national preparation for war, engineers have been self-sacrificing to the point of impoverishment. In the public service and in many cases of private service their inadequate salaries have stood practically still during the war period, where the wages of other labor have doubled and trebled and more. Brains have been at a financial discount; brawn, better organized, has fared better.

Now, with the return of peace, the struggle for existence has been intensified. Civil engineers employed upon the construction and maintenance work of the railroads of this country have received lower compensation than have engine drivers, brakemen and clerks. Many designers in our shipyards have received smaller compensation than the carpenters and mechanics. The laborer who works with his hands has been better paid often than the man who worked with his head. Day

laborers have drawn higher pay during many months than the foreman directing their work. There is no justification, in fact or in productivity, for this condition.

Meanwhile, the purchasing power of our incomes has been nearly halved, or costs have been doubled. This condition must and will pass, though unhappily lack of effective coöperation and of past experience in meeting such situations are likely to delay the transition; but the world recognizes to-day, far better than it did before the war, the character, breadth and scope of the work of the engineer and its dependence upon it.

In public works and public utility service the engineers have too long undervalued their professional service and been content to attach too great weight to continuity of service and long tenure of office.

The constant tendency toward the building up of political machines in our cities has militated against fair treatment of the engineer, to whom, with rare exception, politics are distasteful.

So, too, the development and growth in power of large construction concerns, many of them handling not only the scientific and physical but also the financial elements of their problems, while giving greater opportunity and return to the engineer of exceptional talent, resourcefulness and administrative ability, sometimes tend toward the exploitation of the services of the engineer and make the outlook of the engineering staff as a whole less attractive financially and more keenly competitive. To the man above the median line the outlook is probably much better to-day than ever before; to him below the line, perhaps, worse, certainly but little improved. But the median line is higher and standards of work are constantly being bettered, advance in compensation following of necessity, though often slowly.

Some Causes of Lack of Active Interest in Our Engineering Societies.

As I have attended engineering society meetings in different parts of the country, often when but a handful of men were present to hear a paper prepared with care and labor by some fellow-member, I have asked myself, "What is responsible for the failure of the men to turn out in larger numbers? Where are the younger men?"

Some of the causes are obviously the diversification of interests, specialization, improvement in means of communication, the smaller consumption of time involved in reading or skimming an article instead of listening to its presentation, and perhaps, most important of all, the multiplicity of demands upon our available time.

It is to be remembered too that engineering as a science is young, scarcely half a century old. Many of the pioneers in our profession are happily still with us. The need for coöperation of engineers in such societies was more urgently felt in those early days of the formative period than to-day, because of the lack of precedent, record and knowledge. But the societies themselves have constantly grown in power.

Now comes a new generation of engineers, prepared by the technical schools, instead of by hard experience, able to find good precedent, well-classified knowledge and epitomized statement of the state of the art in many fields of engineering; more sophisticated, but less keen for discovery until competitive struggle challenges courage and awakens ambition. Then real progress begins and knowledge takes on new significance, new value, as it has from generation to generation, to the young man.

The Present Problem of Engineering Societies.

The present problem of engineering societies is that of rousing the younger men to help themselves, of bringing home to them what they will otherwise learn regrettably late, that the engineering societies offer the open door to acquaintance and happy relationships with men of their own profession, to friendly service and effective coöperation, to the development of winsome personality and broader life.

While it is the younger men who suffer from failure to justly appraise the situation, we older men must bring home to them, as would father to son, these obvious facts, clear to us because of our broader experience with life. Many of the younger men do not appreciate these facts. They find it exceedingly difficult to overcome their shyness and to mingle with men to whom they have not previously been introduced. They naturally shrink from putting themselves forward and from making the first

advance, even where they are ready to go more than half way in the effort to meet men. The Society must find a way to overcome this difficulty, for the feeling is a natural one and widespread. It is recommended, therefore, that there be present at every meeting members of the Committee on Activities, conspicuously labeled, who shall act as welcoming hosts and introduce new members to one another, and see to it that no man can feel himself out of the circle or of common touch. Many organizations, like the Chambers of Commerce and Rotary clubs, have recognized this need as a vital one and have succeeded in overcoming the difficulty, supplanting shrinking diffidence with warm-hearted good-fellowship.

It is important, too, that the coming generation of engineers should not lose the advantage already gained in our generation, of the maintenance of friendly relations with one another, even though in active competition. Distinguished foreign engineers, who have visited us, have repeatedly spoken of the marked contrast in this respect, between conditions in the United States and abroad, and of the greater advantage of the cordial relations here existing. We should broaden and strengthen these ties, and make them more helpful.

How can this be done?

Labor Unions Not the Solution.

The fields of the professional society and the labor union are similar to a limited degree only, quite distinct in many respects. The labor union interests itself primarily in the material welfare of its members, — the wages, hours of employment, conditions of work and similar questions. Its success depends upon its power; its power upon its members; its membership upon the breadth of its aims and simplicity of requirements for admission. As mere numbers largely determine its strength, the selective process cannot be carried far in limiting admission to its brotherhood.

The professional society, on the other hand, may advantageously carry the selective process much further, and practical experience has demonstrated that with the development of the state of the art, the process of specialization leads to the

formation of new societies and associations of men highly skilled in narrower fields. While the professional society may establish codes of ethics, general scales of compensation and other measures helpful to the material welfare of the engineer, its primary function must ever be to broaden technical knowledge, to improve engineering methods and standards and to give facilities for the advantageous interchange of professional knowledge, technique and opinions.

The labor union exercises its influence through organized force or economic pressure; the professional society rather through improvement in methods, efficiency and in standards of practice. The means used for accomplishing betterment are in marked conflict in principle and application. There is little hope of their unification. The best that can be looked for is the maintenance of such relations between the engineer's labor union and his professional society that the young engineer who joins the labor union may not be denied entrance to the engineering society at a later date, when his professional spirit has grown and developed and he can discriminate intelligently between the two fields of activity.

Welfare Societies Fill a Limited Field.

While there is room at the present for effective welfare work by strong organizations formed for this primary object, it is not likely to prove possible to carry on collaterally effective work of equal importance in the engineering field. The independent altruistic spirit may go hand in hand with individual effort, commanding public confidence and respect, but question of possible selfish ulterior motive immediately arises, when altruistic spirit attempts to emerge from the spirit of selfish welfare work.

All experience has shown that the most helpful and enduring field of work for the engineering societies must be the educational and professional rather than the personal.

While no doubt organizations devoted to welfare work may build up good reputations for fair consideration of the public interest, as well as that of its members, just as in the field of organized labor certain organizations have the reputation of

being better officered and managed than others and of having scrupulous rather than unscrupulous regard for contractual relations, the building up of the prestige of engineering societies is a much more difficult task. It requires a nice discrimination between feasible and impossible action, between productive and non-productive fields, between desirable publicity and danger of exploitation, and a clear conception of the difference between progressivism and radicalism.

It is particularly important at this time that we should build on the past, safely and wisely, shaping our societies to meet present problems the better, rather than to throw experience of the past to the winds and to embrace supposedly new ideas, often idealistic and attractive in principle, but impracticable of enforcement and therefore visionary.

Interesting the Younger Men to Meet Informally and Discuss Their Problems.

One of the most promising lines of work lies in efforts to bring together effectively in this Society the young engineers of different offices in this city and neighborhood, interested in special problems of design. These meetings should tend to broaden acquaintanceship, stimulate interest and give opportunity for really effective educational work. During the past year this movement was instituted, and three such meetings have been held at which there were presented and discussed some interesting recent problems in foundations for structures on the water front. From thirty-five to fifty of the younger men of the Society attended each of these meetings, and a lively and helpful discussion has resulted. The interest aroused and the response of the younger men have been most friendly and encouraging. Their comment has been favorable and appreciative.

The meetings can probably be made more helpful and the diffidence of the younger men in speaking be better overcome, by limiting the attendance to the younger men with but two or three of the older men, particularly experienced in the subject matter under consideration, present to assist in broadening and drawing out friendly discussion and comparison of ideas.

The discussions can be vitalized by taking up specific actual

problems recently faced by these young engineers in their daily work, with which they are therefore so thoroughly familiar that they can speak upon them informally without effort. Additional meetings can then be held, to broaden the examples of the application of the theories involved. Oral presentations are to be encouraged, rather than written ones.

In this way groups of capable young engineers can be drawn together and activity of interest in the work of the main society be gradually but materially stimulated.

Recent experience indicates further that it would be advantageous either to form a new section of the Society for this purpose, or to appoint a committee largely composed of the more active of the younger and middle-aged men of the Society, interested in this work, with perhaps two of the older men on the committee, who are in sympathy with the movement and whose greater acquaintance and experience would contribute to the breadth and sustained interest in this work.

Effort should be made to bring the older men into friendly touch with the younger men in every way possible and to the advantage of both.

Experience Talks.

Past-President Gow has made a very sensible suggestion that appears worthy of adoption,— that meetings also be held during the course of the year in which some of the more experienced men be asked to give practical talks upon some phases of their engineering experience, their failures and successes, arranging to have others join in the discussion at the same time, to broaden its scope, and using every effort to draw out the younger men. This, too, would tend gradually to bring the younger men into closer touch with the Society, through the informality of the procedure and their interest in such practical matters.

Use of Portion of Income of Permanent Fund for Social Activities.

In view of the rapid advance in cost of living, and consequent inadequacy of current funds, it appears reasonable to use a portion of the income of the permanent fund for social activities, which may bring men into closer touch with one another in ad-

vance of and after the regular meetings. Unless this is done, either the activities of the Society must be curtailed or the dues raised. Action has been taken along this line, by authorizing the Board of Government to make use of the current income of the fund during the year 1919–20. The present as well as the future generation of engineers may justly benefit by these funds.

Student Sections.

It appears desirable to consider further the formation of student sections, either of the Boston Society of Civil Engineers, or perhaps, better, of the national engineering societies, that they may act as natural feeders to these societies and bring home to the student engineer, at as early a date as possible, the advantage that will accrue to him from associating himself with the activities of some engineering society. The appointment of a committee to investigate and report upon this subject may be advisable, although it appears likely that action could more wisely be deferred until the national societies take action upon this subject.

Joint Society Meetings.

Joint meetings with the members of other engineering societies should be encouraged. They tend to broaden interest and acquaintanceship.

Proposed Association of Professional Technical Societies.

A movement has been initiated this year, by this Society, to investigate the desirability of bringing together in some form of association the existing professional engineering societies of this city and vicinity, with a view to drawing engineers of different kinds together, making more effective their organizations and decreasing the financial burdens involved by them. Prof. George F. Swain was appointed chairman of this committee, and report upon the subject is looked for within the next few months. Similar movements have been undertaken and proven advantageous in Chicago, Philadelphia and elsewhere.

Public Service and Welfare Problems.

There appears to be a growing belief on the part of engineers that their engineering societies should take a more active part in the discussion of public matters upon which the engineer is experienced and competent to advise the public. It is to be borne in mind, however, that such work must of necessity be of slow development if the work is to be made effective, owing to the very large amount of time and expense involved, and to the fact that the engineer has relatively little time and money to give to it. A good example of such work, as ambitious in character as it is desirable of accomplishment, is the present effort of engineers, architects, chemists, contractors and others, to bring about the establishment of a National Department of Public Works. Much self-sacrificing and excellent work has been done, and the present outlook for action by Congress is favorable, but it is to be clearly borne in mind that there is grave difficulty in maintaining concerted and effective effort of this sort over long periods of time, and that this movement has had very great financial obstacles to overcome.

Individual Efforts.

It is not to be supposed that the older men are alone responsible for the upbuilding of our engineering societies. This responsibility is shared alike by the younger men. Nevertheless, it is true that the former realize more clearly, as a result of longer experience, the importance to engineers, of active engineering societies, and it is therefore incumbent upon them to bring home this fact to the younger men, that valuable time may not be lost, and that the younger men may not wake up later to a realizing sense of what they have lost in failing to take active part in constructive efforts in this field during their early professional lives.

It is to be clearly remembered that the Society and we, as individuals, benefit only as we put effort into its meetings. Who has not felt the difference between friendly interest and of aloofness and cold criticism at meetings of one kind and another? How are conditions of the whole to be bettered if the individuals

sit by and fail or refuse to act? How often the flood gates of animated discussion have been opened by the courage of one man in asking a question or two, — perhaps a foolish question in the eyes of some. If members would all look at the matter from the point of view of the interest of the Society rather than of their personal feelings, what progress could be made! What vitalizes an organization? What, in the slang of the day, gives it "pep"? The enthusiasm of a few live men and the participation of large numbers of its members in its activities, — participation, I say, and not absorption. Participation involves giving out as well as taking in. Don't be clams, but, like the bee, spread the pollen while you sip the honey, and later share the honey with others.

It is with our societies as with our government. Congressman Dies of Texas, in retiring recently from the House of Representatives after ten years of service, pertinently said upon this subject:

"I wish the farmers of this country and the taxpayers of our land might have a return of the old democratic and republican theory that government is not created to support the people but that it is a creature to be supported by the people.

"The great mistake we are making, my friends, here now, is that we are practicing hypocrisy upon the people. We are leading them to believe that the government can support them and lift them by their boot straps out of their financial difficulties, when, as honest men, we should say to them that all that the government can do is to protect their life and their liberty and tax them to support the government.

"You have taken the fairest and best government ever known among men and you are making it into the most despicable socialism. You took the American people at a time when they believed they could support themselves and their government, and you are teaching them hour by hour and day by day to expect that their government shall support them. . . . It is their duty to support the government, and not the government's duty to support them."

We may well take these words to heart.

Your officers are ready to serve for you, to work for your best interests. They welcome help and criticism. But the criticism must be constructive, not destructive; must be fair

and candid; and you must be ready to do your share in advancing the interests of the Society and the standing of the engineer. Concerted coöperative effort is essential, and I appeal to the younger men of the Society, particularly, to attend the meetings, to join in the discussions, to suggest topics of interest to make our Society a live, vital force.

Show your officers how to make this good old organization a more useful and efficient one. It needs young blood with wit to observe cause and effect and to do straight thinking to the very end. So lend a hand!

Vol. VII MAY, 1920 No. 5

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PAPERS AND DISCUSSIONS

This Society is not responsible for any statement made or opinion expressed in its publications

DISCUSSION OF SMALL SEWAGE PUMPING STATIONS.

By Thorndike Saville,* Member Boston Society of Civil Engineers.

Mr. Leger's paper is an interesting and valuable contribution to a subject which is rather scantily treated in the literature of sewage disposal. It is doubtless due in part to this lack of information concerning the various types of small sewage pumping equipment that has led to the installation in some instances of elaborate devices for the removal of sewage where some of the simpler methods described in this paper would have been less expensive and more satisfactory in operation.

The writer had occasion during 1918 to recommend a method of sewage pumping for the large experimental aëronautical station at Langley Field, Va. This is an elaborately planned permanent field, where the sewage disposal problem was complicated by the fact that the average elevation of the surface of the ground was about six feet above sea level. All permanent houses had toilets or laundries in the basement, and it was impossible to discharge the sewage by gravity into Back River, which adjoins the field. The system finally adopted was to divide the field into two sections for sewage disposal, each section draining into a receiving station from which the sewage was pumped to a disposal plant serving both sections. The general plan of the sewerage system is shown in Fig. 1. In general, there was a strictly domestic sewage to care for, and

* Associate Professor, Hydraulic and Sanitary Engineering, University of North Carolina, Chapel Hill, N. C.

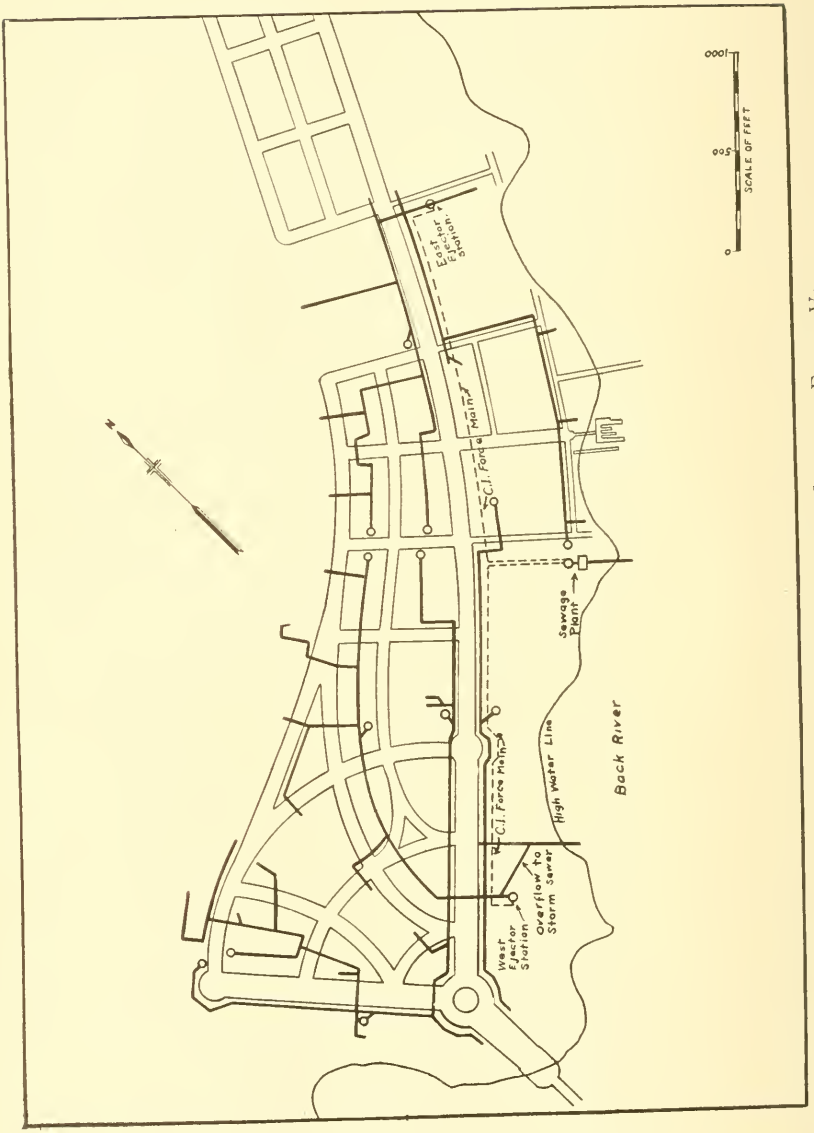


FIG. 1.— SEWERAGE SYSTEM, LANGLEY FIELD, VA.

most of the system consisted of 6-in. pipe laid on a grade of 0.4 ft. per 100 ft., with flush tanks at the ends of all branches and at certain intermediate points. The roads are of concrete, and all road crossings were laid with 6-in. or 8-in. cast-iron pipe. As the various branch lines came together the size of the pipe was increased to 8 in. and 10 in.

The question arose as to the best method of pumping the sewage from the two receiving stations. After a very careful study and inspection of several municipal plants, it was decided to install sewage ejectors of the Shone type. In this particular case, however, a complication arose from the fact that the sewage was to be pumped to a disposal plant consisting of an Imhoff tank and filters. It was thought that the sudden discharge of large quantities of sewage over short periods of time, due to the intermittent operation of the ejectors, might interfere with the proper operation of the Imhoff tank. One method of reducing this rush of sewage was embodied in the Imhoff tank, which was designed by Ford Kurtz, of the J. G. White Corporation. This was to introduce scroll passages at the inlet to the tank, which reduced considerably the velocity of the entering sewage. This has been described in detail in another article.*

A further regulation was suggested by the writer to cause a more constant flow from the ejectors. Ordinarily an ejector installation comprises two units, one of which is held in reserve. It was thought that it might be possible to utilize both units, arranging them to operate alternately. In this way one unit would be filling while the other was discharging, and, if the flow of sewage was sufficient, an almost continuous discharge would pass through the force mains. In addition this would eliminate any backing up of sewage in the mains with consequent possible deposition, since the flow would be by-passed to the other ejector while one was discharging. With the coöperation of Mr. Kurtz and Mr. Yoemans (of the Yoemans Company, who manufacture the Shone ejectors), an alternating valve was devised in the air-supply system, such that the ejectors operated alternately, as described above.

* "Sewage Disposal at Langley Field," by Thorndike Saville and C. L. Weir, *Engineering News-Record*, August 21, 1919.

[Fig. 2 shows the double unit (the East) in a concrete pit 20 ft. below the surface, with an inlet from two directions.] Fig. 3 shows a near view of the West unit. Each pot is of 150 gal. capacity, and the alternating valve is installed. The valve

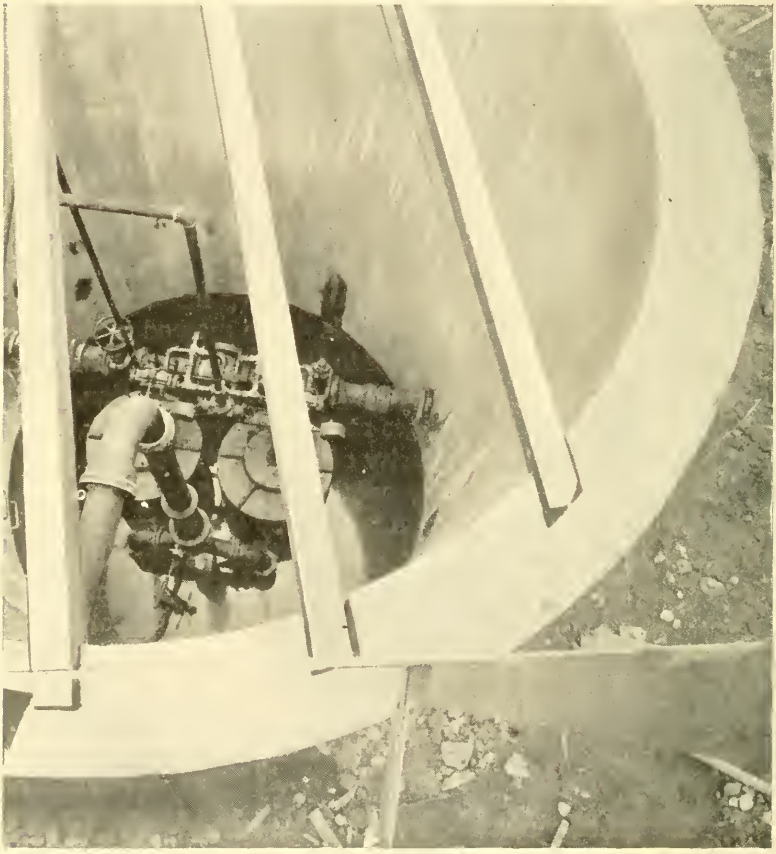


FIG. 2.—SEWAGE EJECTOR (EAST), LANGLEY FIELD, VA.

worked entirely satisfactorily under the most adverse conditions. For a short time, when one of the pits was flooded, the ejector worked under 5 ft. of water. When inspected by the writer last December, after more than a year of operation,

both stations were still serving the purpose for which designed. The valve is so arranged that it can be cut out of action in case of trouble with either ejectors, and the remaining ejector operated in accordance with the usual practice.

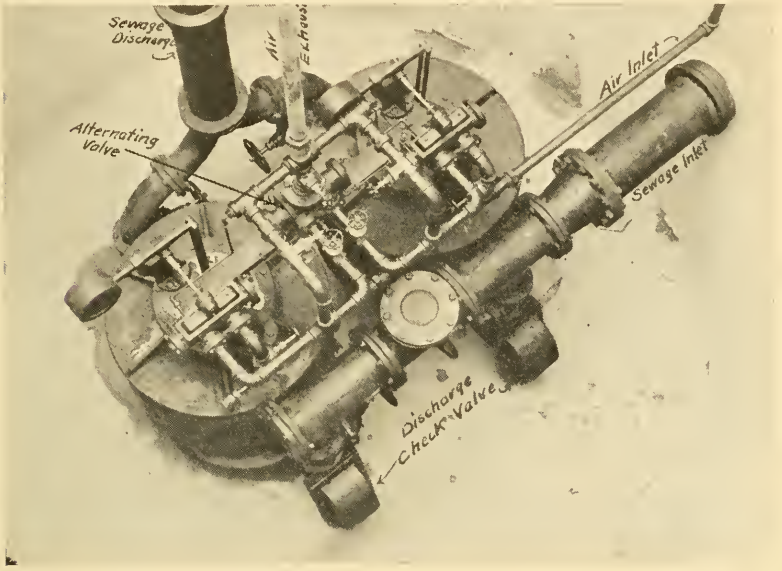


FIG. 3.— SEWAGE EJECTOR (WEST), LANGLEY FIELD, VA.

The general design of the sewerage system was made by Albert Crane and Ford Kurtz, of the J. G. White Corporation. This was subsequently somewhat modified, and the system constructed under the direction of the writer. Capt. J. McInerney was in general charge of construction of the field, and Col. Wm. L. Patterson was commanding officer.

MEMOIR OF DECEASED MEMBER.

EDWARD A. BUSS.*

Mr. Edward A. Buss was born in Peterboro, N. H., May 11, 1856, and died August 18, 1918, at the Homœpathic Hospital, Boston, following an operation, which was successful, but his physical strength, being largely impaired by a nervous attack a year previous, was not sufficient to withstand the shock.

He was the son of George W. and Lyrenea Jaquith Buss. The family moved to Boston when he was quite young. He received his early training at the Boston English High School, graduating in 1872. Later he was a special student at the Massachusetts Institute of Technology, where he was a member of the Class of 1876 for two years, and took a course of training in civil engineering which fitted him for his special line of work. On December 17, 1879, he was married to Mary Cobb Haskell, the only child of Capt. Charles and Mary Black Haskell, whose home was in Auburndale, Mass. Mr. and Mrs. Buss made their home at Hyde Park, and later at Winthrop, Mass.

In 1883, he established a private office of his own as a consulting engineer at 85 Water Street, where, for over thirty-five years, he maintained a useful and successful practice until his death.

He was employed in a consulting capacity by many large manufacturing concerns and interested himself in many large enterprises. For many years he was the consulting engineer for the Great Falls Manufacturing Company of Somersworth, N. H., and did a large amount of work for the Harmony Mills, the Hollingsworth & Whiting Company, the Cranes Paper Mills of Pittsfield, Dwinell and Wright Companies, the Boston Rubber Shoe Company, the Chicopee Water Works and many other large companies.

* Memoir prepared by Henry B. Wood, Edward S. Smilie and Edward P. Adams.

He conducted a model office, and his filing system for periodical engineering literature was thorough and unique. Each number, as received, was separated and so marked and filed by subjects for easy reference that not only was each indexed subject in a folder by itself for easy removal, but any number of each periodical could be reassembled at a moment's notice by his efficient stenographer. The use of this fund of engineering information he generously offered his engineering friends.

In his work he was always painstaking and thorough, more than ordinarily careful as to detail; always the student, he weighed carefully all the factors that entered into each problem and was then able to form an opinion all the more trustworthy because his line of reasoning was well seasoned with common-sense.

Being kindly disposed and always charitable, he was helpful to a large number of people, and, while the principal part of his time was given over to mill construction and extension of large manufacturing establishments, he found an opportunity to devote a large part of his time to public charities. Among others, he became interested in the Morgan Memorial. Its superintendent relates that having occasion to seek technical advice concerning the realization of their water power at South Athol, Mass., he naturally laid the matter before Mr. Buss on account of his kindly interest in the work.

His visit to the factory, the multitude of questions asked, his careful measurements of the stream flow, his insistance that absolute accuracy be obtained through the employment of some reliable surveyor and engineer, and the completeness of his report led the superintendent to express the wish that the "whole institution might be as thoroughly surveyed and studied," although he had no money to pay for such study. Mr. Buss replied, "I will make you that contribution if you think it worth while."

As a result of his investigation, many valuable aids to efficient management were suggested and adopted. A pamphlet was prepared by him and published by the Memorial, giving a complete history of the movement, detailed statements of its name and the scope of instrumentalities employed. Each topic

was arranged in unique and logical sequence, showing to the world that "as a Religious-Charitable Institution it meets the needs of to-day in the light of to-morrow." The Memorial also received the benefit of his financial support. Later he was invited to Brooklyn, N. Y., where the Good-Will Industries were organized along similar lines to the work of the Morgan Memorial, and his interest in this work continued for a long time after its inception.

On September 17, 1902, he became a member of the Boston Society of Civil Engineers.

Of a quiet and retiring nature, he did not form as wide an acquaintance among engineers as some enjoy; but those who knew him best feel that they have lost a good and true associate, whose noble and philanthropic work of these many years stands as a fitting testimony to his loyal devotion to the welfare and best interests of humanity in its broadest sense.

Vol. VII JUNE, 1920 No. 6

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PROCEEDINGS

PAPERS IN THIS NUMBER.

"Thames River Bridge." James W. Rollins.
Memoirs of Deceased Members.

Reprints from this publication, which is copyrighted, may be made provided full credit is given to the author and the Society.

Contributors are hereby notified that proof will not be submitted to them for examination unless requested before the 10th of the month preceding the month of publication.

DESIGNERS SECTION

At a meeting of the Board of Government held April 2, 1920, the following petition was received:

Boston, Mass., March 17, 1920.

To the Board of Government,
Boston Society of Civil Engineers,
Boston, Mass.

Recently there have been held in the Society Library three informal meetings for the discussion of problems of design, particularly for the benefit of the younger members of the Society engaged in design work. The success of these meetings indicates that there is a demand for meetings of this character, and that the usefulness of the Society will be extended by continuing along these lines in a more substantial way, than by informal action, as has been the case thus far.

It is believed that this can be done to the best advantage by the formation of a Section devoted to such a purpose. In this way the movement will be more likely to be self-supporting and permanent, there will be greater

opportunity for the development of the younger men in official capacity, and there will be a greater sense of dignity in the undertaking than would be the case if the matter is handled by a committee.

In view of the above considerations, the undersigned, members of the Boston Society of Civil Engineers, respectfully request the Board of Government in its discretion to establish a Section to be known as,

"The Designing Engineers Section of the Boston Society of Civil Engineers," in accordance with paragraph 13 of the By-Laws.

Respectfully submitted,

(Signed)

Frank A. Marston.	Ralph W. Horne.
Philip W. Taylor.	Carroll A. Farwell.
A. L. Shaw.	John W. Raymond.
Arthur B. Appleton.	Arthur P. Rice.
W. Newell Wade.	Arthur P. Porter.
R. E. Rice.	B. A. Bowman.
H. C. Sheils.	Philip B. Walker.
Howard C. Thomas.	B. A. Rich.
Elmer P. Rankin.	Leroy G. Brackett.
Harrison P. Eddy, Jr.	John P. Wentworth.

K. C. Reynolds.

After a full discussion it was voted unanimously to establish a Section of the Society to be known as "The Designers Section of the Boston Society of Civil Engineers."

S. E. Tinkham, *Secretary.*

Boston, April 7, 1920. — The Board of Government having authorized the organization of a Designers Section of the Boston Society of Civil Engineers, following a petition requesting that action submitted under date of March 17, 1920, with 21 signers, a meeting was called to order, with 23 present, by Secretary Tinkham of the Society.

Mr. Philip W. Taylor was elected temporary chairman, and, following a vote of those present to that effect, appointed the following as a committee to submit nominations for officers and to draft a set of by-laws for the new Section: Messrs. Ralph W, Horne, Ernest D. Mortenson, Arthur L. Shaw, Frank A. Marston. Philip W. Taylor and Carroll A. Farwell.

Mr. B. A. Rich was then introduced and discoursed upon the subject of "Small Concrete Highway Bridges." Many

interesting features of the design and construction of numerous bridges of this character built for the Metropolitan Park Commission were outlined, and the discussion which followed was instructive.

The meeting adjourned at 7.45 P.M.

Reported by

A. L. SHAW.

BOSTON, April 28, 1920. — A meeting of the Designers Section was called to order by Mr. Frank A. Marston in the absence of the temporary chairman, Mr. Philip W. Taylor. Mr. Marston explained that, due to a misunderstanding about the date, Mr. Mark Linenthal, who was to speak on "Concrete Ships," was unable to be present. The meeting then proceeded to the business of the evening.

A motion was made and seconded that Mr. Marston act as temporary chairman, and was unanimously carried.

Motion was made that Howard C. Thomas act as temporary clerk. Motion carried.

Mr. Marston then read the report of the Committee on Nominations, appointed at the meeting of April 7, 1920.

It was moved and seconded that this report be accepted and that the Clerk be instructed to cast one ballot for the men nominated. The Clerk cast the ballot, and the following officers were declared elected:

Chairman — Ralph W. Horne.
Vice-Chairman — Ralph E. Rice.
Clerk — Arthur L. Shaw.

Additional members of Executive Committee:

Philip W. Taylor.
Henry C. Sheils.
Frank A. Marston.

Mr. Marston then retired in favor of the chairman-elect, Mr. Horne, who thanked the men for his election, and predicted a bright future for the Section if every one does his part.

The report of the Committee on By-Laws was read by

Mr. Horne. Each section was then discussed and action taken as shown in detail in the proposed By-Laws.*

It was moved and seconded that the By-Laws as amended go into effect upon approval by the Board of Government and this Section. Motion carried.

It was moved and seconded that the Clerk transmit a copy of the By-Laws to the Board of Government for approval. Motion carried.

It was also moved and seconded that the Clerk record the names of all members present at the meeting. Motion carried.

It was moved and seconded that all members of the Boston Society of Civil Engineers who were signers of the petition of March 17, 1920, to the Board of Government, all members of the Society who have presented their names to the Secretary of the Society as interested in this Section, and all members present at this meeting, shall be considered as the charter members of the Section. The motion was carried.

It was moved and seconded that the Clerk be instructed to include in the records of this meeting a copy of the petition of March 17, 1920, to the Board of Government for the organization of this Section, the action of said Board and a statement of the business of the meeting of April 7, 1920.

Chairman Horne then closed the meeting with a few well-chosen remarks, urging all members to push the Section, suggest speakers and subjects, and to take an active part in discussions. It was recommended that each member upon addressing the Chair give his name and the firm with which he is connected, in order that the members might become more readily acquainted.

Meeting adjourned at 7.45 o'clock.

HOWARD C. THOMAS,
Temporary Clerk.

* The By-Laws of this Section, as approved by the Board of Government May 19, 1920, are appended hereto.

BY-LAWS OF THE DESIGNERS SECTION.

ARTICLE I.

SECTION 1. The object of the Designers Section of the Boston Society of Civil Engineers shall be the professional improvement of its members through informal discussions on the design of engineering works, and the encouragement of social intercourse particularly among the younger members of the Society.

ARTICLE II.

SECTION 1. The membership of the Designers Section shall consist of Members, Juniors and Associates.

SECT. 2. Eligibility to office and the right to vote shall be limited to the membership of the Section.

ARTICLE III.

SECTION 1. Members, Juniors and Associates of the Boston Society of Civil Engineers shall be entitled to membership in this Section as Members, Juniors and Associates, respectively, upon making written application to the Executive Committee of the Section.

SECT. 2. Members, Juniors and Associates of the Boston Society of Civil Engineers, who are not enrolled as members of the Section, shall be entitled to attend all meetings of the Section and take part in the discussion of professional subjects, but shall have no vote.

ARTICLE IV.

SECTION 1. The officers of this Section shall be a Chairman, Vice-Chairman and Clerk.

The general government of this Section shall be vested in an Executive Committee, consisting of the President of the Boston Society of Civil Engineers, the Chairman, Vice-Chairman, Clerk and three others from the membership of the Section.

SECT. 2. The Chairman of the Section shall represent the Section at the meetings of the Board of Government of the Boston Society of Civil Engineers, with the privilege accorded under its By-Laws.

SECT. 3. The term of office of all officers and committees shall extend to the next succeeding annual meeting or until their successors are elected or appointed.

SECT. 4. All officers and committees shall assume their duties immediately after the close of the meeting at which they have been elected.

SECT. 5. Vacancies occurring in any office may be filled by ballot at the first meeting after notice of the same has been sent to each member, a majority of the votes cast being necessary to elect.

ARTICLE V.

SECTION 1. The Chairman shall have a general supervision of the affairs of the Section. He shall preside at meetings of the Section. In case of his absence or a vacancy in his office, the Vice-Chairman shall discharge his duties.

SECT. 2. The Executive Committee shall have control of the management of the Section, subject to the action of the Section at any meeting, and shall make the necessary arrangements for all meetings. All questions in Executive Committee shall be decided by a majority vote, and four members shall constitute a quorum. Meetings of the Executive Committee shall be held at the call of the Section Chairman, or, in his absence or inability to serve, at the call of the Vice-Chairman.

SECT. 3. The Clerk shall keep the records of the meetings of the Section and of the Executive Committee, and perform such other duties as are herein prescribed and as may be required by the Executive Committee. He shall prepare and transmit to the Secretary of the Boston Society of Civil Engineers notices of all meetings and copies of the records of all meetings, papers and discussions.

SECT. 4. No expenditures shall be made or financial obligation incurred by any officer or committee of the Section, for which the Society will be responsible, without previous authorization by the Board of Government or President of the Society.

ARTICLE VI.

SECTION 1. The annual meeting of the Section shall be held in Boston on the second Wednesday in March, at which meeting the annual reports for the preceding year shall be presented and the officers for the ensuing year elected.

SECT. 2. The officers and other members of the Executive Committee shall be elected at this meeting by written ballot, from nominations made from the floor, or submitted in writing previous to the meeting and endorsed by at least ten members.

SECT. 3. The regular meetings of the Section shall be held on the second Wednesday of the months of October to May, both inclusive, unless otherwise provided by the vote of the Executive Committee.

SECT. 4. Special meetings of the Section shall be held at the call of the Chairman. At special meetings no business shall be transacted, unless announced in the call for the meeting and upon recommendation of the Executive Committee.

SECT. 5. Ten members shall constitute a quorum for the transaction of business.

ARTICLE VII.

SECTION 1. Proposed amendments to these By-Laws shall be submitted in writing to the Executive Committee, and shall be presented to the Section at a regular meeting, if so decided by vote of the Executive Committee. The Executive Committee shall, however, bring before the Section any proposed amendment at the written request of ten members.

SECT. 2. Announcement of a proposed amendment which is recommended by the Executive Committee or by ten members of the Section shall be given by printing the amendment in the notice of the regular meeting. A two-thirds vote of the members present and voting shall be necessary for the adoption of the amendment.

SECT. 3. All amendments to these By-Laws shall receive the approval of the Board of Government of the Boston Society of Civil Engineers before taking effect.

BOSTON, May 12, 1920. — A meeting of the Designers Section of the Boston Society of Civil Engineers was held in the Society rooms and was called to order at 6.00 P.M. by the Chairman, Ralph W. Horne.

The report of the previous meeting was read and approved.

Mr. Mark Linenthal was then introduced and covered his subject, "Concrete Ship Construction," in a most entertaining and instructive manner. The success of his efforts was attested by the general and active discussion which followed in the audience which numbered 25.

The meeting adjourned at 8.30 P.M.

Respectfully submitted,

A. L. SHAW, *Clerk.*

LIST OF MEMBERS.

ADDITIONS.

CAMERON, EDWARD H.,
Care Jackson & Moreland . . 387 Washington St., Boston, Mass.
HOGUE, C. J. 3734 Grand Central Terminal, New York, N. Y.
JOHNSON, WILLIAM A. 710 City Hall Annex, Boston 9, Mass.
LONGFELLOW, GEORGE P. 112 Chandler St., Boston, Mass.
PITMAN, M. EDGAR 708 City Hall Annex, Boston 9, Mass.

CHANGES OF ADDRESS.

BAILEY, F. S. 14 Hillcrest Rd., East Braintree 84, Mass.
BEUGLER, E. J. The Foundation Co., 120 Liberty St., New York, N. Y.
COBURN, S. E. 47 Berlin St., Wollaston, Mass.
EWING, W. C. American City Bureau, Tribune Bldg., New York, N. Y.
FARWELL, C. A. P. O. Box 462, Springfield, Mass.
FLETT, L. E. 10 Almont St., Medford 55, Mass.
GILLETT, L. A. 92 Bromfield St., Newburyport, Mass.
KIDD, A. L. 74 Grampian Way, Dorchester, Mass.
MACKSEY, H. V. Supt. Dept. of Public Works, Framingham, Mass.
SHEDD, G. G. 92 Park Ave., Manchester, N. H.
VAN DER PYL, EDW. 5 Erickson St., Worcester, Mass.
WALKER, P. B. Church St., Whitinsville, Mass.
WEBB, G. F. P. O. Box 147, Austell, Ga.
WHITMAN, RALPH,
Care Bureau Yards and Docks, Navy Dept., Washington, D. C.

DEATHS.

BROWN, WILLIAM M. May 28, 1920.
BURKE, JOHN R. April 27, 1920.

APPLICATIONS FOR MEMBERSHIP.

[June 15, 1920.]

THE By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

Allen, Herbert Bullard, Fitchburg, Mass. (Age 40, b. Gardner, Mass.) From 1904 to 1908 with the Sewer Department, Worcester, Mass., as assistant chemist under H. P. Eddy; from 1908 to 1914 chemist in charge of the testing of materials and other chemical and photographic work in connection with the extension of the sewer system of Louisville, Ky.; from 1914 to 1918 assistant chemist for sewage disposal, Fitchburg, Mass.; and from 1918 to date chemist in charge of Sewage Disposal System, Fitchburg, Mass. Refers to H. P. Eddy, A. L. Fales, D. A. Hartwell and F. A. Marston.

Cove, Earle Howard, Readville, Mass. (Age 22, b. Oxford, Nova Scotia, Canada.) Educated in Everett High School 1914–15, and Northeastern College 1917–18; general engineering practice three years prior to 1918; transitman with the N. Y., N. H. & H. R. R., Feb., 1918, to Aug., 1918; transitman with Metcalf, Aug., 1918, to Feb., 1919; chief of party with G. H. Wetherbee, Jr., Feb., 1919, to Feb., 1920; chief of party with the Town of Watertown, March, 1920, to May, 1920, and since May, 1920, with Fay, Spofford & Thorndike. Refers to F. S. Bailey, W. T. Barnes, W. F. Learned, F. A. Marston, F. J. Maynard and G. H. Wetherbee, Jr.

Kennison, Karl Raymond, Boston, Mass. (Age 34, b. Marysville, N. B.) Graduate Colby College, Waterville, Me., June, 1906, and graduate of Mass. Institute of Technology, in Mechanical Engineering, June, 1908. Draughtsman with American Bridge Co., East Berlin, Conn., until Sept., 1906; with inspection department, Association Factory Mutual Ins. Co., Boston, as draughtsman, surveyor and sub-assistant, until June, 1909; draughtsman with J. R. Freeman until Sept., 1909; instructor in mathematics and drawing at Colby College, introducing new technical courses, until June, 1910; assistant resident engineer at Holter Dam, Mont., also in charge of river gagings, until Dec., 1910; principal assistant to J. R. Freeman on water supply and water-power projects, in charge of designs, estimates and survey, until Oct., 1915; assistant engineer, Water Supply Board, Providence, R. I., on new water supply and power development now under construction, until Jan., 1918; supervising engineer, Bureau of Yards and Docks, at Blake & Knowles Works, East Cambridge, in charge of extensive plant additions, until June, 1918; supervising plant engineer, Emergency Fleet Corporation, Mobile, Ala., in charge of construction of new concrete shipyard, until Dec., 1918; assistant plant engineer, Emergency Fleet Corporation, in charge of Middle Atlantic District office until May, 1919; and in charge of western section of Southern District to May, 1920: in charge of construction of 10 000-ton dry dock and repair plant at New Orleans, 10 000-ton dry dock and piers at Mobile, 5000-ton dry dock at Pensacola, and other less important constructions. Is an associate member of Am. Soc. of Civil Engineers. Refers to Harold K. Barrows, Bertram Brewer, Frederick Otis Clapp, John R. Freeman, J. Arthur Garrod, X. H. Goodnough, Ralph H. Stearns, Joseph F. Wilbur, Frank E. Winsor.

THE M. I. T. CO-OPERATIVE PLAN A PROVED SUCCESS.

For the past year an interesting experiment in coöperative engineering education has been conducted by the Massachusetts Institute of Technology and the General Electric Company. While the coöperative scheme in itself is not new, several departures from the usual plan were introduced, which have produced decided results.

The class was limited to thirty students, who were chosen entirely upon the records which they had made in the equivalent of the first two years' work of the Electrical Engineering Course at Technology. Included in this group were graduates from Yale, Harvard, Dartmouth, Princeton, the Naval Academy, besides men who had completed their first and second years solely at Technology. The year (12 months) is divided into four three-month periods, the students spending alternately thirteen weeks at the Lynn works of the General Electric Company and eleven weeks at the Institute, followed by a two weeks' vacation. The group at Lynn is housed together in a fine old residence which has been converted into a modern clubhouse. No break is made in the major studies when the students are at Lynn, — courses being conducted at the Works in Principles of Electrical Engineering and in General Studies. The progress of the students through the plant is regulated not by the production needs of the various departments but by the advantage which the experience in each department is to the students.

The result of this year's work has been gratifying to the originators of the plan. Because the students were a selected group, were all taking the same course, and were thrown together intimately at work and at the clubhouse, an intense spirit of loyalty to one another, to the Institute and to the General Electric Company soon became manifest, and every man strove to make a reputation for the course. With the students attacking the work in this frame of mind, it is not surprising that their enthusiasm was soon shared by the officials and superintendents of the coöperating company, who are unanimous in stating that the work done in the shops has been preëminently satis-

factory. As evidence of its approval of the work, the company has increased the number of men who can be enrolled in this year's class to sixty and has already secured a new clubhouse in order to furnish rooming accommodations for them. The new class which has already nearly completed its quota of members will enter upon the work July 6.

LIBRARY NOTES.

Recent Additions to the Library.

U. S. Government Reports.

Accidents at Metallurgical Works in the United States, 1918. Albert H. Fay.

Absorption as Applied to Recovery of Gasoline Left in Residual Gas from Compression Plants. W. P. Dykema and Roy O. Neal.

Anticlines near Maverick Springs, Fremont County, Wyoming. A. J. Collier.

Approved Explosion-Proof Coal-Cutting Equipment. L. C. Ilsley and E. J. Gleim.

Architectural Concrete Stone and Concrete Blocks in 1917 and 1918. G. F. Loughlin.

Asbestos in 1918. J. S. Diller.

Asphalt and Allied Substances in 1918. C. C. Osbon.

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Boiler and Furnace Testing. Rufus T. Strohm.

Census of Electrical Industries, 1917.

Cement in 1918. Ernest F. Burchard.

Coal-Mine Fatalities in the United States, 1919. Albert H. Fay.

Copper in 1917. (General Report.) B. S. Butler.

Data of Geochemistry. Frank Wigglesworth Clarke.

Deposits of Manganese Ore in Nevada. J. T. Pardee and E. L. Jones, Jr.

Determination of Mercury. C. M. Bouton and L. H. Duschak.

Gold, Silver, Copper, Lead, and Zinc in California and Oregon in 1918. Charles G. Yale.

Gold, Silver, Copper, Lead, and Zinc in Colorado in 1917. Charles W. Henderson.

Gold, Silver, Copper, Lead and Zinc in Utah in 1918. V. C. Heikes.

Iron Ore, Pig Iron and Steel in 1918. Ernest F. Burchard.

Mineral Resources of the United States, 1917.

Mineral Waters in 1918. Arthur J. Ellis.

Mining in Northwestern Alaska. S. H. Cathcart.

Manganese and Manganiferous Ores in 1918. D. F. Hewett.

Mining in the Matanuska Coal Field and the Willow Creek District, Alaska. Theodore Chapin.

Potash in 1918. W. B. Hicks.

Report of the Chief of the Weather Bureau, 1918–19.

Secondary Metals in 1918. J. P. Dunlop.

Strontium in 1918. George W. Stose.

Surface Water Supply of the United States in 1916. Nathan C. Grover, chief hydraulic engineer.

Talc and Soapstone in 1918. J. S. Diller.

Work on Mineral Resources done by the U. S. Geological Survey. Edson S. Bastin and H. D. McCaskey.

Waste and Correct Use of Natural Gas in the Home. Samuel S. Wyer.

Zinc in 1917. C. E. Siebenthal.

State Reports.

Connecticut. Annual Report of the Highway Commission, October, 1918, to June 30, 1919.

New York. Report of the Investigation and Study of the Route of the Improved Erie Canal between the Cities of Tonawanda and Buffalo.

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New York. Supplemental Report of the Jamaica Bay–Peconic Bay Canal Board.

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New York. Report of the State Engineer and Surveyor J. A. Bensel on Surveys of Black River Canal Extension, Chemung Canal Reconstruction, Glenns Falls Feeder Conversion, Flushing River and Jamaica Bay Canal Construction, and Newtown Creek-Flushing Bay Canal Construction.

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Vol. VII JUNE, 1920 No. 6

BOSTON SOCIETY OF CIVIL ENGINEERS
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PAPERS AND DISCUSSIONS

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THAMES RIVER BRIDGE.

By James W. Rollins,* Past President, Boston Society of Civil Engineers.

(Presented April 21, 1920.)

The problem of constructing a bridge across the Thames River at New London was a most complex one, the river being about 1 400 ft. wide, the water 50 ft. deep at the center of the river, and rock bottom 100 ft. to 180 ft. below water level.

When the question of a bridge at this location was first discussed in 1856, it was considered to be beyond the limit of finance and the engineering resources of the day, and not until 1889 were these difficulties removed and the bridge built and opened to traffic with proper ceremonies on October 10 of that year.

It was a double-track structure, 1 432 ft. long, with a draw span of 503 ft., this span remaining the longest in the world for many years.

The plan for constructing the deep foundations was a novel one and compares most favorably with very recent practice for timber grillage foundations, and it is rather difficult to see why the foundations were not more permanent.

The work was done in this way: First, the soft mud was dredged out to a depth of 20 ft. below the bottom of the river. A crib of 12 ins. by 12 ins. hemlock timber was built, with 8

*Of Holbrook, Cabot & Rollins, 6 Beacon St., Boston, Mass.

center pockets, each about 20 ft. by 8 ft., without bottoms, but with loading pockets on the outside. This crib was sunk to the dredged bottom of the river. Piles, sufficient in number to carry the load of masonry and superstructure, were then driven in the center pockets. These piles were of Oregon fir and

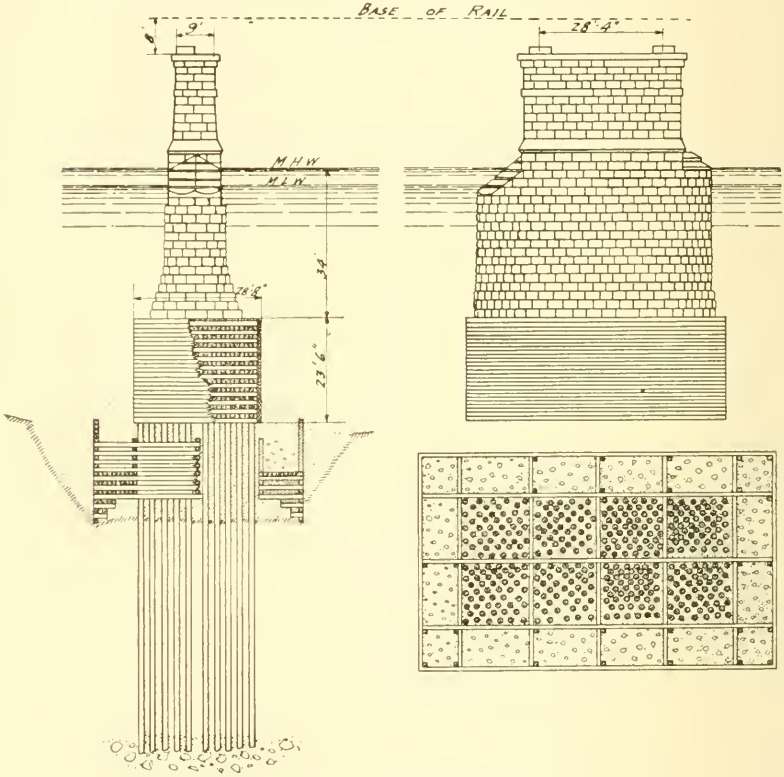


Fig. 1. — Pier in Original Bridge.

yellow pine, 60 ft. to 80 ft. in length, and were sawed off by a water machine saw at depth of 60 ft. below water surface.

The work of sawing off the piles was, according to notes of the engineers, the most difficult part of the work.

The masonry was built in timber caissons, with a thickness of bottom timber (rough hemlock) of 23 ft. in center piers, with

the usual timber side for open-caisson construction. On account of the great thickness of the grillage, 23 ft., some difficulty was met in keeping the caissons from tipping over.

About 1905 the old bridge began to move, and some of the piers settled to such an extent that in 1908 the traffic was cut down to a single "gauntleted" track.

The movement of the old bridge foundations is described as follows by Mr. W. H. Moore, engineer of structures, of the New York, New Haven & Hartford Railroad Co.:

"Shortly after the bridge went into service, Pier No. 1, counting from the west end, began to settle, the total settlement, if I remember, being some 18 ins. to 24 ins. This pier was founded on a gravel bed which was exposed at low water. Piles were driven through the gravel and cut off, I think, about 3 ft. or 4 ft. below the surface. When the settlement took place, Mr. Dawley drove several rows of piles all around the pier and built masonry on these piles, which was built into the pier so as to underpin it and distribute the pressure to the new pile work. No subsequent settlement of this pier took place.

"The pivot pier settled unevenly and very slowly, tipping toward the southeast in a plane approximately at 45 degrees to the axis of the bridge. This tipping did not disturb to any great extent the elevation of the top of the pier. Several times during the life of the bridge we have moved the swing span bodily on the top of the pier to bring the center of the turntable back into the axis of the bridge, at the same time leveling up the bearings for the wheels. This movement shortened the distance between the pivot pier and easterly rest pier while lengthening the distance between the pivot pier and the westerly rest pier, so that, from time to time, we had to cut off portions of the superstructure at the east end to maintain a proper clearance for operating the bridge. After this movement had proceeded for a considerable amount, the bearing of the westerly end of the draw span was coming so close to the edge of Pier No. 2 that we built up a concrete facing on the east side of this pier some 18 ins. wide, reënforced with steel columns and tied securely into the pier.

"The movement of the pivot pier was rather peculiar; sometimes it would move at a practically uniform rate for several years and then would come a period of five or six years during which no movement was noted. Then again it would begin to move. I tried to check up these irregular movements with the periods at which heavier engines were purchased and

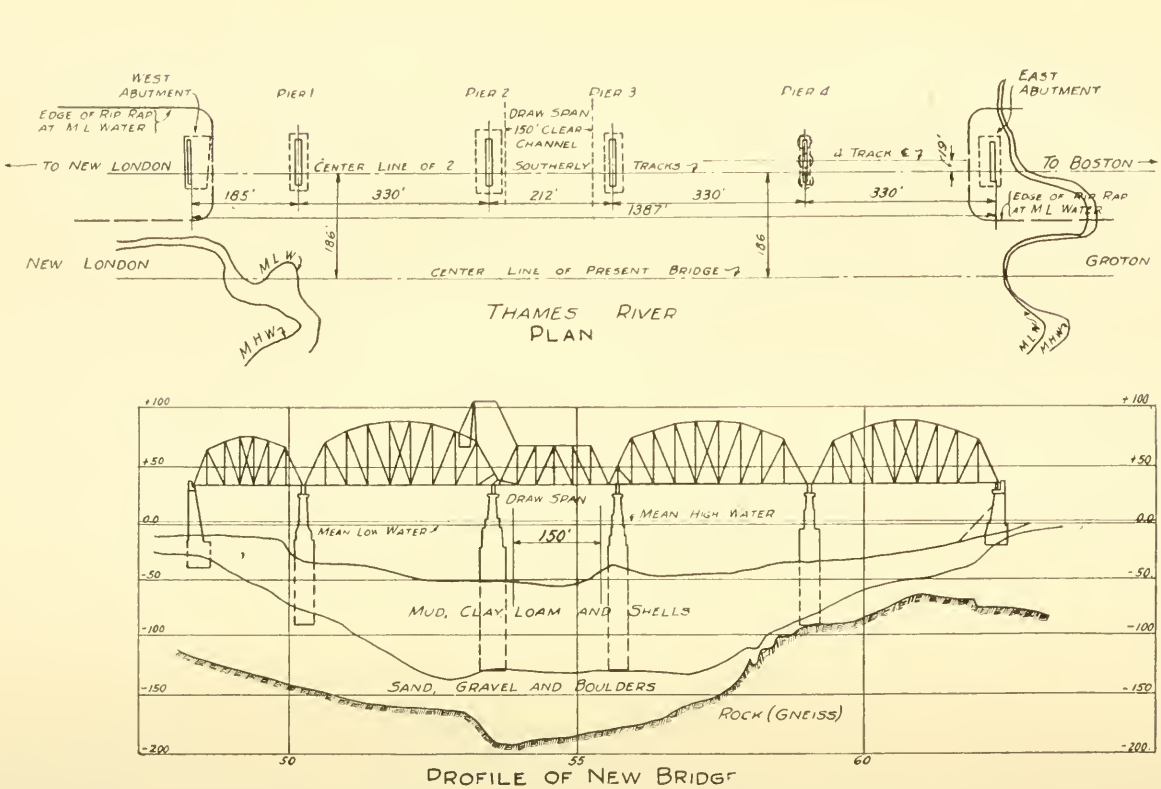


FIG. 2. — PLAN AND PROFILE OF NEW BRIDGE.

put into operation on the Shore Line, but the periods did not seem to coincide closely enough to warrant the definite statement that movements began after heavier engines were put on. However, I think that this had something to do with the starting of the periodical movements."

Studies were then begun for a new bridge. A profile of the river bottom at the site of the new bridge is given. (Fig. 2.)

Various studies were made as to type of foundations: First, a pile concrete grillage, open-caisson type; but this was finally abandoned on account of the failure of the old bridge, which was built in this way.

At the request of one of the engineers of the N. Y., N. H. & H. R. R., the writer at one time made a study, report and estimate of this type, and is still of the opinion that a modern type of construction of the pile open-caisson method would have have been as satisfactory and stable and much less expensive than the open-crib construction plan, which was finally used.

The worst condition affecting the piers was in the center of the river, where the water was 50 ft. deep, mud and clay 80 ft. thick — a total distance of 130 ft. to suitable gravel foundation.

The writer's plan was to dredge out 20 ft. of mud, fill the hole up 10 ft. with crushed stone, and then drive piles 75 ft. long through the crushed stone into hard gravel and sand stratum, sawing off piles at −60, filling up balance of dredged bottom with riprap to −50, the original bed of river.

The masonry would then have been built on a concrete reënforced grillage sunk on to the piles.

The writer believes that in the consideration of this type for foundations some question arose as to the effect of this dredging and pile driving on the old bridge foundations, the center lines of the two bridges being only 186 ft. apart, and possibly this fear led to the abandonment of the pile open-caisson method.

A four-cylinder open caisson was also studied, but abandoned on account of the doubts as to being able to control the sinking of these cylinders to the great depth necessary.

The final and accepted study was for rectangular open-crib caissons, and after most extensive borings had been made the

final plans were drawn, bids were asked for, and contract awarded to Holbrook, Cabot & Rollins Corporation in March, 1916.

The terms of the contract were somewhat novel, and were as follows:

The contractor guaranteed that the cost of the foundations according to the plans submitted would not exceed eight hundred and seventy-five thousand dollars, that any excess cost above that sum was to be paid by the contractor, and any saving of cost below the above sum would be divided equally between the contractor and the Railroad Company. The contractor was to be given a fixed fee of eighty thousand dollars for doing the work.

This plan worked out most satisfactorily, as the Railroad Company paid at once for all material bought, and under these conditions we bought all the material for the whole job, and piled it up for use as needed; so that with the possible exception of gravel for concrete, we did not have to wait at all for material.

Another great advantage in this form of contract where both the company and the contractor had a direct money interest in the cost (as we divided the saving) was the close and cordial coöperation between engineers and contractor, to do the work in the most economical manner. Everybody worked for the best interest of the job; no pet schemes or new theories were tried out, for we all realized that we had a most difficult problem, which was a new one for all of us, and that it needed thought, brains and the most diligent attention, in order to be carried through with success.

Apart from the paper proper, a new thought comes to the writer in thinking over this form of contract. It is common practice now to make contracts of a fixed fee basis, with a provision for division of saving, and the new thought is to divide the saving into thirds: one to the company, one to the contractor, and the third to the *engineer*. This might work out to the benefit of all, and the writer is sure that any reputable contractor would be glad to give up 17 per cent. of his bonus, to help a worthy and helpful engineer.

The contract plans provided for two abutments on gravel

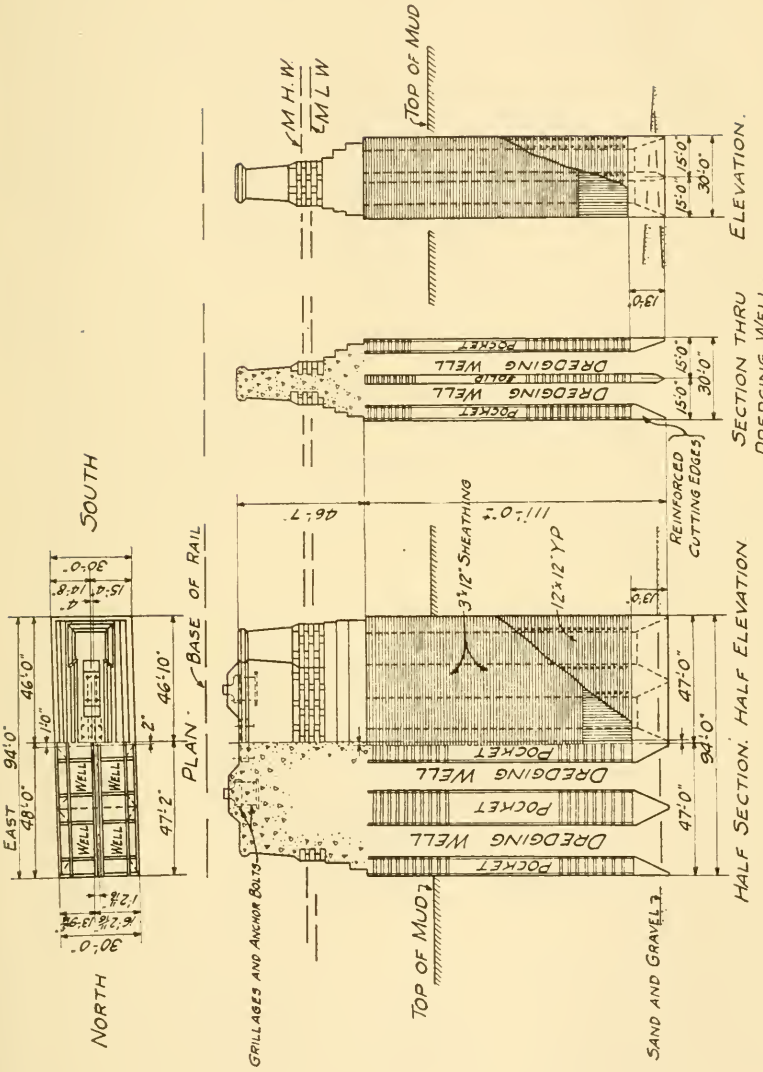

SOUTH
NORTH
EAST
PLAN
BASE OF RAIL
WELL
POCKET
DREDGING WELL
REINFORCED CUTTING EDGES
3½" SHEATHING
12"x12" YP
GRILLAGES AND ANCHOR BOLTS
TOP OF MUD
SAND AND GRAVEL
M.H.W.
M.L.W.
ELEVATION.
SECTION THRU DREDGING WELL
HALF SECTION. HALF ELEVATION

FIG. 3. — PIER 3.

foundations: the westerly abutment 40 ft. below water, the easterly abutment 20 ft. below water; and for four piers: three open cribs sunk to hard gravel, 90 ft., 130 ft. and 131 ft. respectively, below water, and the fourth pier built on three pneumatic foundations sunk to solid rock, from 60 ft. to 90 ft. below water. Pier 3, as typical, is shown in Fig. 3.

Plans of cribs showed an alternate design for cutting edge, of wood or of reënforced concrete, and on account of the probable difficulty in making all the mitre joints in heavy timber, it was decided to build the cutting edges of reënforced concrete. Fig. 4 is a plan of the bottom section of the crib, showing cutting edges, and Fig. 5 photograph of crib under construction.

A problem at once developed as to how to build these concrete "cutting edges," which were 42 ft. by 99 ft. in outline, and 13 ft. high, containing 700 cu. yds. of heavily reënforced concrete, and weighing 1 500 tons; with the necessary caisson sides built on to the cutting-edge section, the combined structure drawing 30 ft. of water, when there were no launching ways available for that depth of water and the cost to build special ways for this work was prohibitive.

There was available a ship railway with an extreme draught of 20 ft., and consideration was given to some method of construction which would permit the use of this railway on which to build these cutting-edge sections.

It was at once seen that use must be made of the air spaces in the dredging wells for flotation, for with this space available the *draught* of the cutting edge section was reduced to 13 ft.

This was done by building a solid floor of 4-in. plank on heavy cross timber, this floor being calked on the bottom, and then building the entire crib on this plank floor, making a water-tight connection between the floor and the outside cutting edge, and finally holding the floor tight to the crib by cables from the 12 in. by 12 in. cross timbers on which the floor was built, up to timber across the top of the crib.

To hold the pressure against the false bottom at the open spaces at the bottom of the dredging wells, heavy trusses were built into the concrete in all the dredging wells, so constructed as to allow their removal after the false bottom was released from the crib. These trusses are shown in Fig. 6.

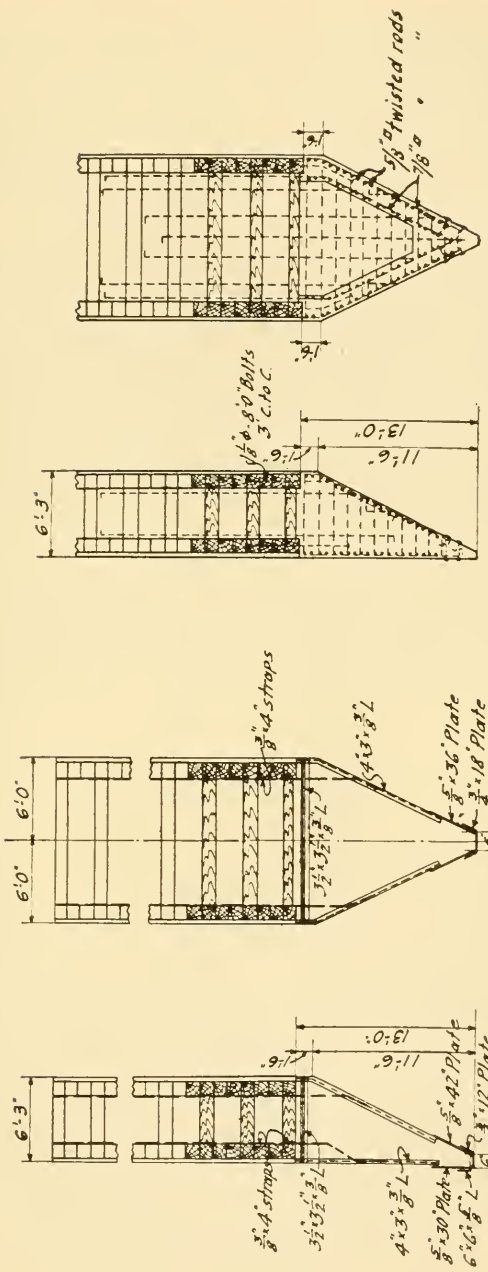


FIG. 4. — SECTION OF CRIB SHOWING CUTTING EDGES.



Fig. 5. — Cutting Edge of Pier 3 on Railway, showing Reinforcement.

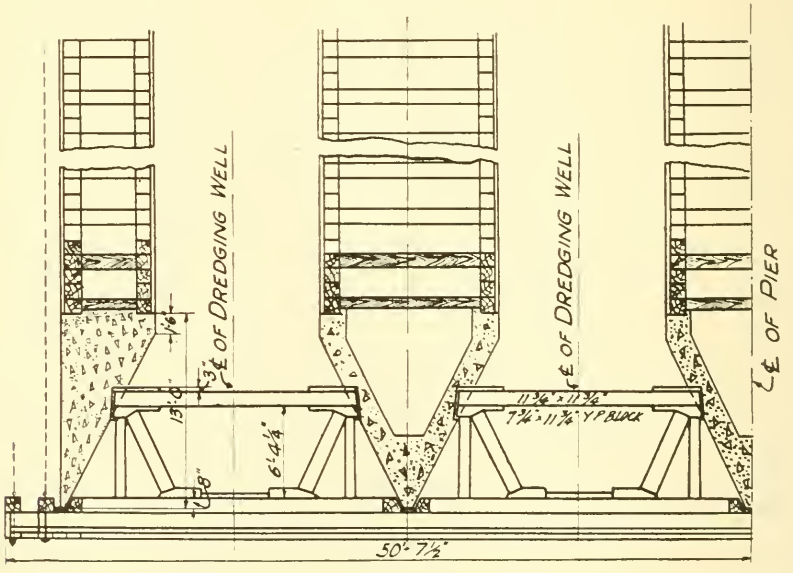


Fig. 6. — Method of Construction of False Bottom.

This plan was entirely successful, and cribs were built on the ship railway to about 20 ft. in height, floated off the railway and towed to the site of the work, and then built up to a height of about 40 ft.

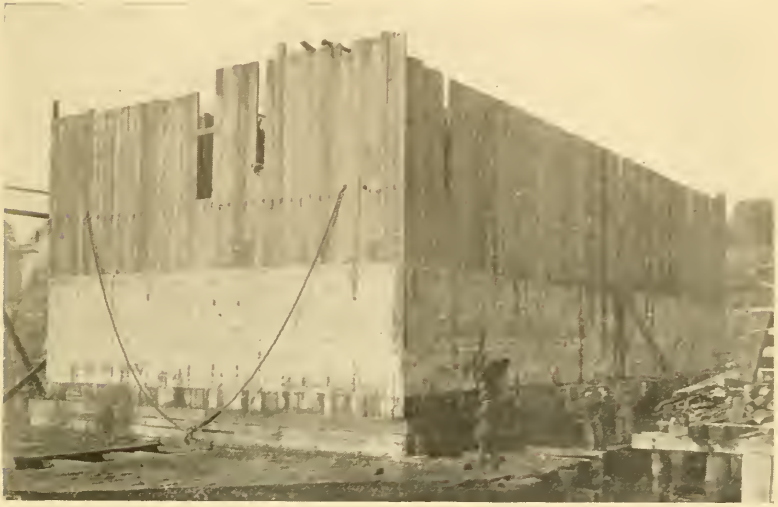


Fig. 7. — Crib on Railway, Ready for Launching.

To detach the plank bottom, the cables were loosened, and clay dumped through the dredging pockets on to the temporary floor, and when enough was dumped to overcome the flotation of this floor, it was detached from crib and dropped to the bottom of the river, and then the crib was towed into its final position, ready for sinking.

The crib proper was built of 12 in. by 12 in. timber, solid on the outside, with one longitudinal and one lateral timber, every third timber being an independent course on the outside of the crib, and around the dredging wells.

The longitudinal and laterals were halved at connection with the outside timbers of the crib, but only drift-bolted on all interior connections.

Serious trouble developed on account of the weakness in the interior connections at the dredging wells. When the tem-

porary bottom of Pier 2 was knocked loose and the dredging wells began to fill with water, the crib began to sink, and finally brought up on the bottom of the river, in 50 ft. of water, with the top timbers of the crib about 12 ft. under water; and, to add to our misfortune, this crib was sunk on the exact site of Pier 2. We then were up against the proposition of raising a crib weighing 2 000 tons, sunk in 50 ft. of water; and right here began the coöperative working of brains and ingenuity, to solve the problem.

First it was asked: Why did the crib sink? And after a little talk and brain work, the question was answered. When the false bottom was loosened from the crib the water filled the dredging wells, which were water-tight, and this brought the resultant hydrostatic pressure on the sides of the dredging wells, which were surrounded by open air spaces, which later were to be filled with concrete.

The sides of the dredging wells of 12 in. by 12 in. timber were only fastened together by two $\frac{3}{4}$ in. by 18 in. drift bolts, and these could not hold the pressure of the water, so the joints in the corners of the dredging well opened, and the water filled the air spaces, so entirely voiding the flotation power of the crib, with the 1 500 tons of concrete on the bottom cutting-edge section.

We sent divers down to examine the wreck, and they reported that the crib was practically level and the false bottom had not been entirely knocked loose from the crib, and when the crib sunk it went back on to the plank bottom in practically its *original position.*

Luck was surely with us in this, for otherwise it would have been practically impossible to float the caisson, and would have necessitated its destruction and removal — a wrecking job of appalling possibilities, especially as the wreck was on the site of Pier 2.

However, with this false bottom in place, our proposition was easy. We built a section of the crib, about 12 ft. high, floated it into position, and with weights sunk it on to the top of the submerged crib. As all pieces were alike in the crib, this section exactly fitted on to the submerged crib, and we clamped it down on to the lower section with bolts and cables, and calked

the joint with divers; also we went over the old joint between the crib and the false bottom and calked that tight. This construction brought the top of the crib above the water level, and then all we had to do was to pump out the water in the dredging wells, and the crib floated.

Fig. 8 shows crib for Pier 3 in place.



FIG. 8. — CRIB FOR PIER 3 IN PLACE.

In this way we very easily got out of what might have been a most serious calamity.

To provide for some small control in sinking the cribs through 80 ft. of mud, clay and gravel, and to help relieve the friction, an elaborate set of jets was built in the cutting edges: two jets in the walls of each dredging pocket, in diagonal corners, and three on the outside of the crib on each side, at the ends and in the center. The pipes were 4-in. in diameter, with nozzles of cast iron made to connect with these pipes, the opening in nozzles being $\frac{3}{4}$ in. All the pipes in a dredging well were connected into one pipe at the top of the dredging well, which pipe was built around the entire top of the caisson, and to which was coupled a compound duplex pump, 14 ins. by 20 ins. by 12 ins.

by 15 ins., with a 12-in. suction and 8-in. discharge, with a capacity of 1 130 gals. per minute at 165 pressure. This pump was installed on a flat boat, with a boiler of 250 h.p. furnishing steam at 150 lbs. pressure to run the pump. (Fig. 9.) Although much time and money were spent on this jetting system, it was not a success, for the power in the jets was not enough to do efficient work in clay, and after a short time this plan was abandoned, and a single vertical pipe was used with a horizontal pipe at the bottom, 2 or 3 ft. long, with a nozzle, of 1¼ ins. With all the power concentrated on to one nozzle tremendous pressure was developed which fairly tore the bottom of the river up, undermining bowlders and everything else within its reach. This single jet pipe was very flexible, as we could lower it into any pocket, or on the outside of the crib at any point where we thought the crib was being held up.

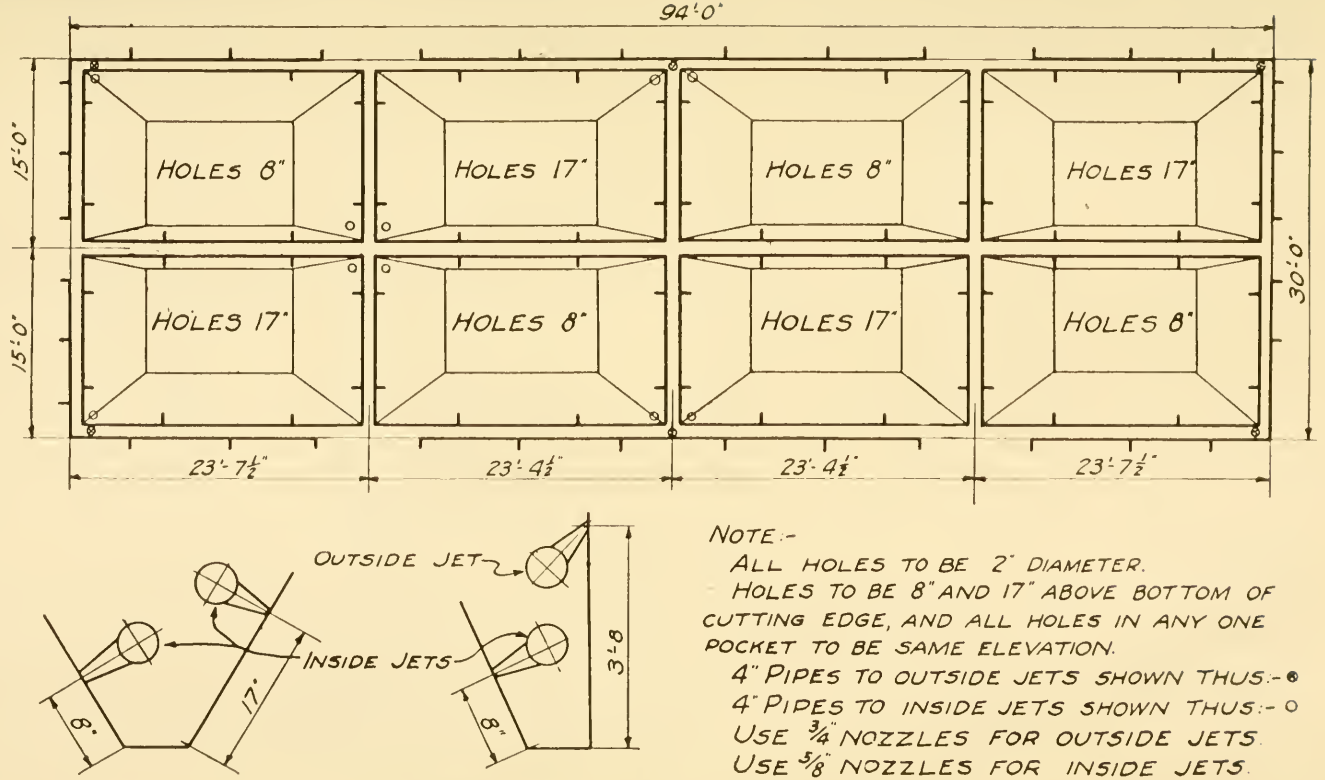
Pier 2 took an ugly slant when about 100 ft. down, and it took a lot of "jockeying" of the crib, using a jet, excavating in the necessary pockets, and loading others with concrete and stone, until finally the crib was sunk to grade and straightened up, with the result that it was about 2 ft. out of position. As this caisson was 42 ft. wide there was plenty of room for adjustment of this variation. In a gravel stratum it was easy to control the sinking of the crib, but the clay at times seemed to vary in consistency, and tend to make the crib slip.

As before stated, Piers 1, 2 and 3 were founded on wooden cribs sunk by dredging through open well, into a gravel stratum 90 ft. to 130 ft. below water level, the rock in this section of the river being from 145 ft. to 185 ft. from water level.

For Pier 4 a rock bottom was attainable at elevation −70 to −100, the rock surface dropping up stream across the foundation at an approximate angle of 25 degrees. (Fig. 10.)

The original plan was for two cylindrical piers, 28 ft. in diameter. On account of the great declivity in the rock this plan was abandoned and three cylinders of 22 ft. adopted; the tops of the cylinders being at grade −9, and the solid masonry pier beginning at that elevation.

These cylinders had a heavy metal cutting edge, with an air shaft in the center 8 ft. in diameter. (Fig. 11.) The outside shell



NOTE:-

ALL HOLES TO BE 2" DIAMETER.

HOLES TO BE 8" AND 17" ABOVE BOTTOM OF CUTTING EDGE, AND ALL HOLES IN ANY ONE POCKET TO BE SAME ELEVATION.

4" PIPES TO OUTSIDE JETS SHOWN THUS:- ⊗

4" PIPES TO INSIDE JETS SHOWN THUS:- ○

USE ¾" NOZZLES FOR OUTSIDE JETS.

USE ⅝" NOZZLES FOR INSIDE JETS.

FIG. 9. — ARRANGEMENT OF JET NOZZLES.

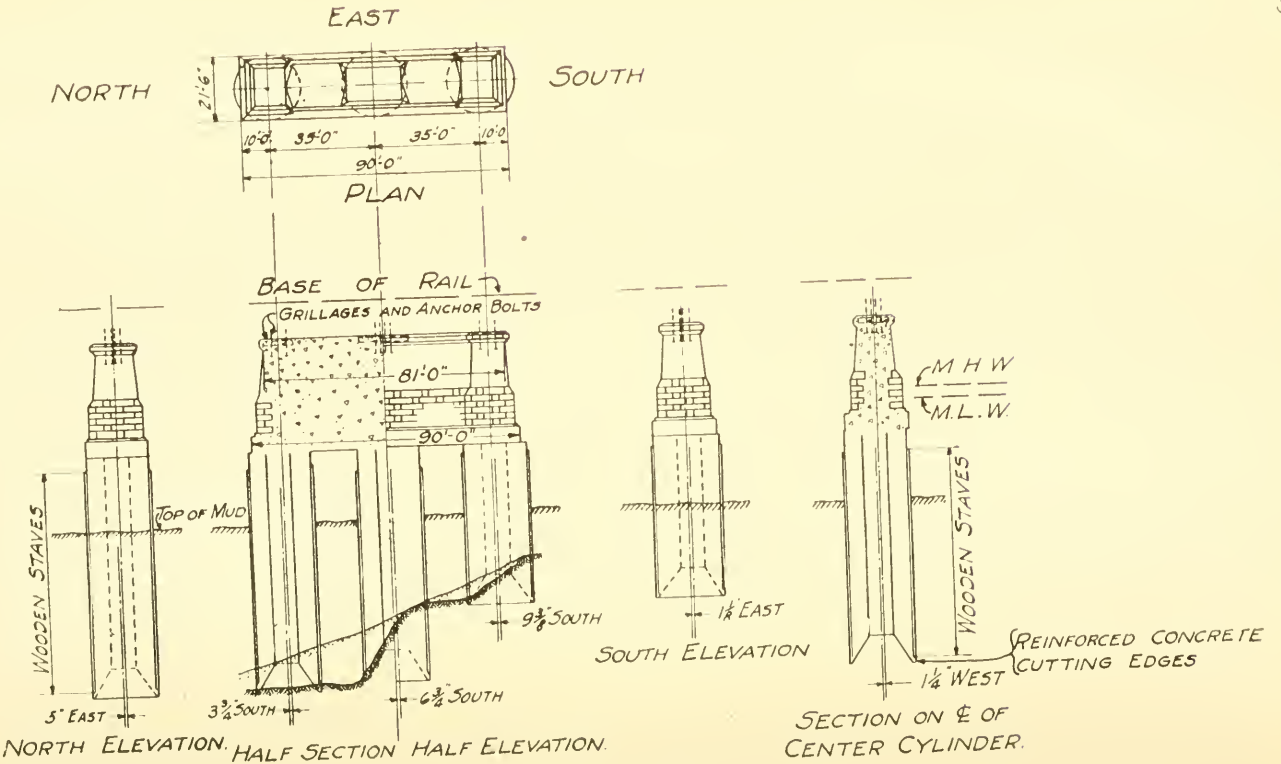

EAST
NORTH
SOUTH
21'-6"
10'-0"
35'-0"
35'-0"
10'-0"
90'-0"
PLAN
BASE OF RAIL
GRILLAGES AND ANCHOR BOLTS
81'-0"
90'-0"
WOODEN STAVES
TOP OF MUD
5" EAST
3¾" SOUTH
6¾" SOUTH
9⅜" SOUTH
NORTH ELEVATION.
HALF SECTION
HALF ELEVATION.
1⅛" EAST
SOUTH ELEVATION
M H W
M.L.W.
WOODEN STAVES
REINFORCED CONCRETE CUTTING EDGES
1¼" WEST
SECTION ON ℄ OF CENTER CYLINDER.

FIG. 10. — PIER 4.

above the plate iron cutting edge, which was 15 ft. high, was built of wooden staves 4 ins. thick, with suitable bands or hoops on the inside to which the staves were bolted, these outside staves being braced like a wheel's spokes to the iron air shaft. (Fig. 12.) These cylinders were built on the marine railway to a height above flotation line, launched and floated down the river to the bridge site. (Fig. 13.)

This was another interesting problem. The water at this pier was 35 ft. deep, with a stratum of mud, shells and clay 20 ft. thick below that, making the proposition of a cofferdam around the cylinders an expensive one, requiring 55 ft. to 60 ft. sheeting.

The final plan was to sink the cylindrical caissons to rock by pneumatic process, build the masonry to grade −9, and then fill up the air shafts and pockets with concrete, leaving the timber sides in position above high water. (Fig. 14.)

A very accurate survey was then made of the relative position of the three piers, and plans drawn showing the results.

We then made a rectangular caisson of heavily reënforced concrete, 22 ft. by 90 ft., and 6 ft. high, and which we christened the "bathtub"; this caisson was about 4 ft. larger each way than the base of the masonry pier which was to be built on it. In the bottom of this caisson we left holes about 15 ft. in diameter, the centers of these holes corresponding to the center of the cylindrical piers already sunk. Cross walls were built in the caissons cutting out these holes, so as to get sufficient air space for the flotation. (Figs. 15 and 16.)

We then built light caisson sides at the top walls and air pockets of the "bathtub," for safety in towing and handling. This bathtub caisson was also built on the marine railway and launched from it.

We had built in the top section of the cylindrical piers a large number of heavy reënforcing rods, and bent them over, so as to float the caisson into position. We also built into the concrete of the piers a piece of rubber hose to act as a gasket to keep the water out of the open pockets in the caisson.

When all was ready we floated the "bathtub" off the railway, towed it down river to the bridge site, and warped it

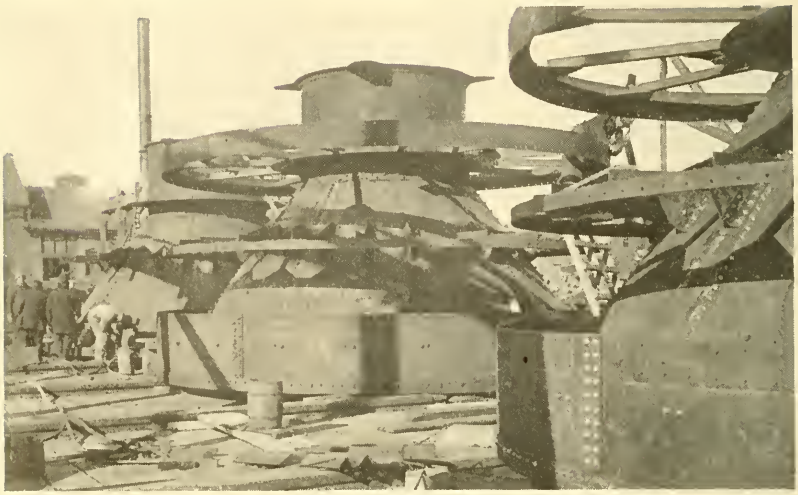


FIG. 11. — CUTTING EDGES, PIER 4.

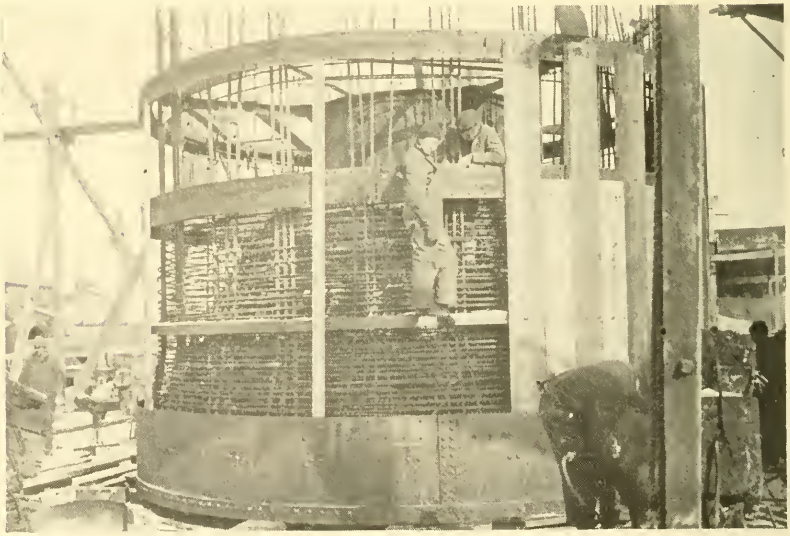


FIG. 12. — PIER 4. CUTTING EDGES, SHOWING HEAVY REINFORCEMENT AND STAVES.



FIG. 13. — CAISSONS FOR PIER 4 ON RAILWAY, READY TO LAUNCH.

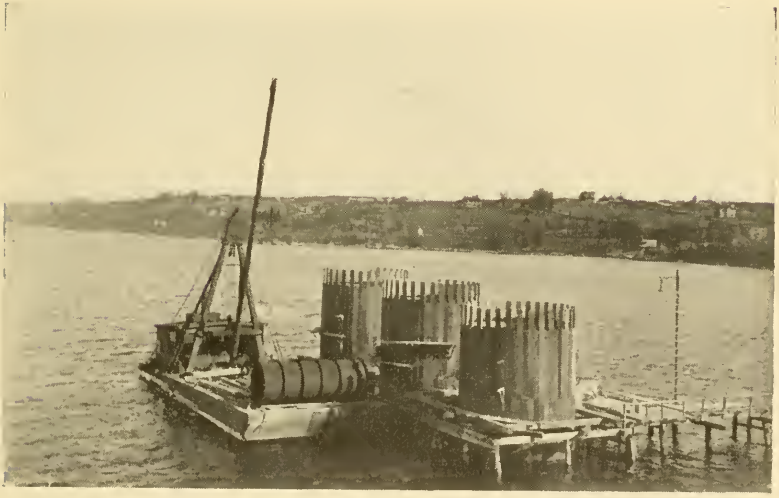


FIG. 14. — CAISSONS FOR PIER 4, SUNK TO ROCK BOTTOM.



FIG. 15. — BOTTOM FOR BATHTUB ON RAILWAY.

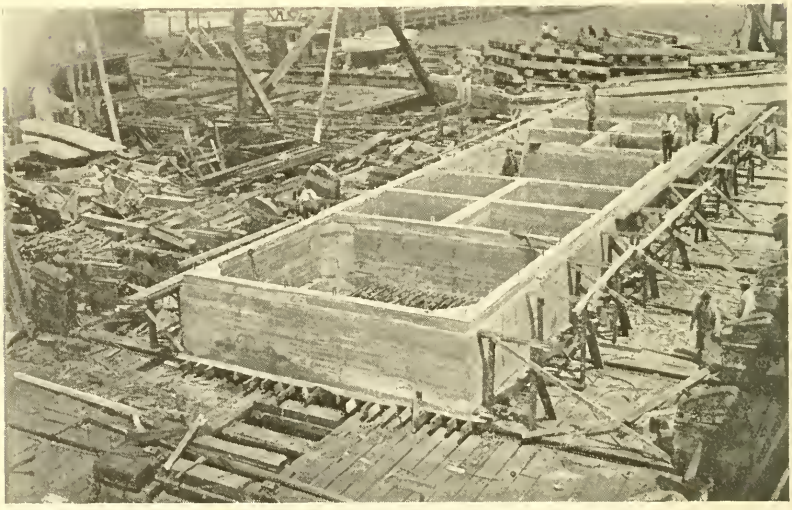


FIG. 16. — BATHTUB FINISHED, READY FOR LAUNCHING.

into exact position over the three foundation piers, and then sunk it on to them. The gaskets worked well, and we had no difficulty in pumping out the open pockets in the "bathtub," straightening out the reënforcing rods, and filling the whole structure with concrete up to elevation −3.76, the bottom of the masonry, finishing that to above high-water level, then removing the wooden sides.

The construction of the piers above the high-water mark

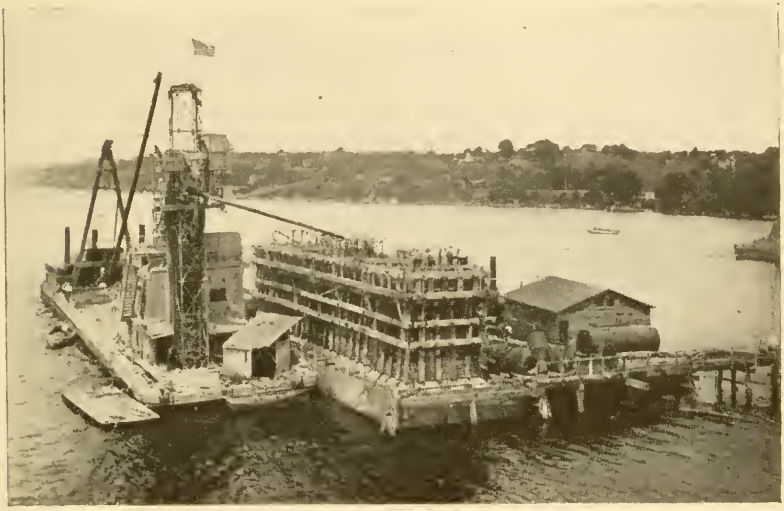


Fig. 17. — Pier 4, Masonry Done and Forms in Place for Concrete Superstructure.

was ordinary water work, and was completed without any trouble.

The granite belt consisted of six courses, which protected the piers against action of the water between tidal limits. To maintain and preserve the joints in the granite masonry, the joints were calked hard with "wool lead."

The plant for this job was very extensive and met fully all the requirements of the work.

The concrete, of which there was 57 000 cu. yds. used, was all mixed in a floating mixing plant, an old car-float, the "Coney

Island," 195 ft. by 35 ft., with a derrick at one end, space in the center for storage of 300 tons of sand and gravel. Under the decks below this storage pile was a 24-ft. belt conveyor which carried the sand and gravel to the front end of the boat into an elevator carrying the material up into a hopper, 30 ft. above the deck. The material was dropped from this hopper into the concrete mixer and into a bucket, at bottom of a tower. The mixed concrete was raised in the tower and spouted into place in the piers, or into a bucket on the lighters for final handling.

Fig. 17 shows the " Coney Island " at Pier 4.

When we got the caissons down to a foundation satisfactory to the engineers, we began to fill up the dredging pockets, which were 8 ft. by 12 ft. in section, and 130 ft. deep. We deposited the concrete through a 12-in. tremie, up to +60, and then pumped the water out and finished the concrete in the wells in the " dry."

When we pumped the water out of the first dredging wells we found to our dismay about 8 ft. of " laitance " on the top of the concrete. We had some difficulty in getting this out on account of the free lime present, and the heat the moving of the laitance developed. Again, the men did not relish working down in that shaft, 80 ft. deep, with a bucket going up and down over their heads. We, later, excavated this laitance with a clamshell bucket, before it had set up, and had no more serious trouble from this cause.

The statistics, in part, on this bridge are as follows:

Total length of bridge, 1 387 ft.; being made in five spans, from west to east, of 185 ft., 330 ft., 212 ft. draw-span, 330 ft., 330 ft., respectively.

The work on the foundations was begun April 20, 1916, and was finished August 9, 1917, 57 114 cu. yds. of masonry being placed at an average cost, including everything, of $16.36 per cubic yard.

The total weight of the load on superstructure is estimated at 5 175 tons, and was erected at a total cost of $162.00 per ton.

All the work on these foundations was done under the direction of engineer's office of the New York, New Haven & Hartford Railroad: Mr. Edward Gagel, chief engineer; Mr. W. H. Moore, engineer of structures; Mr. I. D. Waterman,

engineer of construction; Mr. P. B. Spencer, resident engineer; Mr. W. H. Law, chief inspector. And for the contractors, Mr. Luke S. White acted as superintendent, and Mr. Fred Logan, assistant superintendent; the writer representing Holbrook, Cabot & Rollins Corporation, the contractors.

The description of the original bridge is quoted from the report of Alfred P. Boller, chief engineer, New York, Providence & Boston Railroad Co., dated January 1, 1890. The figures and plans of the new bridge are from the engineering records of the New York, New Haven & Hartford Railroad Co., through the courtesy of Mr. Edward Gagel, chief engineer, Mr. Moore and Mr. Spencer, assistants.

MEMOIRS OF DECEASED MEMBERS.

JOHN STACEY HUMPHREY.*

John Stacey Humphrey was born in Marblehead, Mass., April 21, 1877, the son of Eleazer L. and Addie C. (Magoun) Humphrey.

The family moved to Laconia, N. H., in 1887 and from there to Lynn, in 1891. The boy received his education in these cities, completing his high-school course in Lynn and graduating from the Lynn Classical High School in June, 1894.

He entered the employ of the City of Boston in 1895, and worked under the direction of Mr. H. W. Foss in the coördinate survey of the Dorchester District. In 1901 he left the employ of the City of Boston to work for the Commonwealth of Massachusetts on the Metropolitan Water Supply at Clinton, and the following year left Clinton to work for the School House Commission in the City of Boston. He made a special study of the cost and construction of buildings and acted as consulting engineer for many building contractors, which led to his employment with William Crane, building contractor, as engineer and estimator. While with William Crane he was very successful and considered an authority upon cost and building construction. The buildings which were erected under his supervision while with William Crane were the Mechanic Arts High School, Parkman Memorial situated on the Boston Common, and the east and west wings of the State House. During the war the barracks at the aviation school, Cambridge, and the hospital building at Chelsea were built by Mr. Crane under his supervision.

In the fall of 1918 he severed his connection with William Crane and entered the employ of D. Cunningham & Son, and was employed in erecting other hospital buildings in Chelsea for these contractors at the time of his death.

* Memoir prepared by Clarence B. Humphrey and Frank O. Whitney.

He became a member of the Boston Society of Civil Engineers, December 18, 1912.

He was married in August, 1902, to Z. Maude Bowlby, and is survived by his wife and two children, John S. and Elizabeth A. He died at his home in Swampscott on February 5, 1919, after an illness of ten days, with Spanish influenza.

Mr. Humphrey was a member of the Pendragon Club of Lynn, Boston City Club, and Wayfarers' Lodge, A. F. & A. M., Swampscott.

FRANK LOUIS FULLER.*

Frank Louis Fuller was born July 11, 1848, in Needham, now Wellesley, and died at his home in Wellesley Hills, January 30, 1920. He was the son of Hezekiah and Emmeline (Jackson) Fuller. His death was very sudden and caused by an affection of the heart, he having been in good health up to a few minutes before the summons came to give up an exceedingly active life for a well-earned rest.

Mr. Fuller graduated from the Massachusetts Institute of Technology with the degree of S.B. in 1871, and at once took up his chosen life work as civil engineer, in which profession he was actively engaged until the day of his death. He had an office in Boston, but the sphere of his work extended into nearly all of the New England States.

Among his most important works were the original designing and construction or additions to systems of water supply in Acton, Arlington, Marblehead, Methuen, Monson, Shirley, Waltham, Ware, Webster, West Brookfield, Winchendon and Uxbridge in Massachusetts; Franklin, N. H.; Brattleboro, Northfield and Woodstock, Vt.

He became a member of this Society on June 8, 1874, being one of the large number who assisted in the revival of the Society's work at that time, and was an unusually regular attendant at its meetings, participating freely in the discussion of papers presented and in that way adding materially to the information contained in the original papers. He was one of

*Memoir prepared by John C. Chase.

the nine made life members about a year ago, in consideration of their services in the revival of the Society forty-five years previously, and was the third of the number who have since passed away.

He was a member of the American and New England Water Works associations, taking a great interest in and being a most regular attendant at the meetings of the last-named organization, contributing papers of interest and taking an active part in the discussions. He was also a member of the American Public Health Association, the Sanitary Section of this Society, the Wellesley and the Congregational clubs, and the Appalachian Mountain Club. He was a member of the Wellesley Hills Congregational Church and had served as one of the deacons for many years. He had been a member of the Wellesley Water Board since 1887 and had been its chairman for the greater portion of the time.

In 1881 he married Miss Julia L. Morrill, of Boston, who survives him.

Mr. Fuller was a high-toned Christian gentleman in all that the term implies. Whatever his hand found to do, that he did without inattention or evasion. Although having passed the three score and ten limit of the Psalmist he was not an old man, merely advanced in years, always genial and courteous with his associates of whatever age. In his decease the Society has lost a valuable member, who will be greatly missed by those with whom he has been intimately associated for nearly a half century.

Vol. VII SEPTEMBER, 1920 No. 7

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PROCEEDINGS

PAPERS IN THIS NUMBER.

"Concrete Road Construction." A. N. Johnson.
Memoir of Deceased Member.

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Contributors are hereby notified that proof will not be submitted to them for examination unless requested before the 10th of the month preceding the month of publication.

APPLICATIONS FOR MEMBERSHIP.

[September 15, 1920.]

THE By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members

as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

Etter, Harold Pearson, Boston, Mass. (Age 23, b. Redding, Calif.). Jan., 1916, to May, 1918, University of California, civil engineering. Jan., 1919, to June, 1920, Mass. Institute of Technology, B.S. degree in C. E. Summer, 1917, rodman with McLoud River R. R. Co., Calif.; summer, 1918, assistant, surveying M. I. T. Summer Camp; summer, 1919, surveying and drafting with J. R. Freeman, Providence, R. I. Since July, 1920, with Stone & Webster, Boston, drafting. Refers to J. B. Babcock, 3d, J. R. Freeman, F. M. Gunby, Leonard Metcalf and C. M. Spofford.

Harsch, Erwin, Cambridge, Mass. (Age 25, b. Cincinnati, O.) Graduate Central High School, Washington, D. C., 1911. Graduated from George Washington Univ., 1915, degree of B.S. in C.E. Employed as aid, U. S. Coast and Geodetic Survey, Feb. to Sept., 1913; June to Oct., 1914; and June, 1915, to Sept., 1916. Sept., 1916, to Dec., 1917, instructor in C. E. University of Tennessee. June to Sept., 1917, junior engineer, U. S. Engineer Dept. on Arkansas River Survey. Dec., 1917, to Oct., 1919, ensign (later lieut. j.g.) U. S. Naval Reserve Force. Upon release entered M. I. T. and was graduated June, 1920, with degree of B.S. in C. E. At present, draftsman with Fay, Spofford & Thorndike. Refers to J. B. Babcock, 3d, C. B. Breed, F. H. Fay, H. B. Luther, C. M. Spofford and S. H. Thorndike.

Morgan, George Bason, Cambridge, Mass. (Age 24, b. Greenville, Tex.). Graduate Greenville High School, 1913. One year academic work in Burleson College, 1914. Texas A. & M. College, 1914–18, degree of B.S., C. E. With New York Public Service Comm. four months of 1917. Enlisted in U. S. Army, Nov., 1917, College Sta., Texas, C. of E., 2d Lieut., 1918. Discharged, Aug., 1919. At Mass. Institute of Technology Oct., 1919, to June, 1920; received degree B.S., C. E. At present in Managerial Dept. of Stone & Webster. Refers to J. B. Babcock, 3d, E. F. Rockwood, C. M. Spofford and D. M. Wood.

EMPLOYMENT BUREAU.

The Board of Government maintains an employment bureau for the Society, to be a medium for securing positions for its members and applicants for membership, and also for furnishing employees to members and others desiring men capable of filling responsible positions.

At the Society rooms two lists are kept on file, one of *positions available* and the other of *men available*, giving in each case detailed information in relation thereto.

Men Available.

No. 498. Age 28. Has had about six years' experience in construction plant equipment work. Desires position requiring knowledge of the above work or outside work.

No. 499. Age 27. Received certificate from Wentworth Institute. Experience, three years on mold loft drafting; one year as assistant superintendent on construction; two years as assistant master builder; one and one-half years on designing and drafting. Desires position as superintendent or assistant of construction.

No. 500. Age 41. Educated in Boston public schools, English High School and Harvard University, Class 1901; courses in general science and engineering, economics and general culture. Experience, fifteen years with Middle Western Railroad Co.; six years, general surveys, construction, maintenance and betterment; seven years, bridge construction; three years in charge of all surveys, estimates and recommendation for temporary and permanent bridge renewals, especially economic study of choice of type and traffic necessity for light or heavy, temporary or permanent structure. One year, sales engineer for pre-cast concrete of all types. One year, construction and operation on munitions plant. Two years, miscellaneous construction. Desires position on the planning and direction of development and betterment where railroad and concrete experience may be useful, in Boston or vicinity, but will consider any location.

LIST OF MEMBERS.

ADDITIONS.

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Brown, W. I. 710 City Hall Annex, Boston, Mass.
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Cole, H. S. 16 Winthrop St., Framingham, Mass.
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Gateley, F. J. 12 Rowell St., Dorchester, Mass.
Hannan, W. E. 2 Westmoreland St., Dorchester, Mass.
Holmes, F. O. 703 City Hall Annex, Boston 9, Mass.
Kinsman, H. L. 54 Marathon St., Arlington, Mass.

LYNCH, D. J. 113 Dakota St., Dorchester, Mass.
MONAGHAN, L. J. 45 Stoughton St., Dorchester, Mass.
MORRILL, G. P. 80 Boylston St., Boston, Mass.
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WEBB, DEW. C. Office of Public Works Officer, Navy Yard, Norfolk Va.
WHITMAN, RALPH U. S. Naval Ordnance Plant, South Charleston, W. Va.
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Vol. VII SEPTEMBER, 1920 No. 7

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PAPERS AND DISCUSSIONS

This Society is not responsible for any statement made or opinion expressed in its publications

CONCRETE ROAD CONSTRUCTION.

By A. N. Johnson.*

(Presented January 28, 1920.)

Before passing to the discussion of construction details proper it does not seem out of place to say a word as to the general conditions that control all highway construction.

The large road offerings during last year, and the yet larger ones pending for 1920, compel a consideration of factors that previously did not enter seriously into plans for construction of any type of pavement. But to-day the large amount of work which is to be done makes so great a demand upon all resources, transportation, production of materials, labor and contractors' organizations, that it is imperative that every advantage be taken to conserve and make as effective as possible each of these controlling factors. Of all of them, transportation or car supply is the most limited and will, therefore, control the amount of road actually completed in 1920.

The fact that in the spring there are more open-top cars available than at other times during the year emphasizes the necessity that maximum use be made of all cars that may be available during April and May for the transportation of road-making materials and the storage of the same to be used in construction later in the season. The United States Bureau of Public Roads took the lead last fall in outlining the situation to

* Consulting Highway Engineer, 111 West Washington Street, Chicago, Ill.

the state highway departments, urging them to let contracts as early as possible, so that contractors, in turn, would be able to give orders for materials and equipment.

Such a program necessitates other changes from our procedure in the past. Payments to the contractor would necessarily have to be made, so that he might receive a due amount for materials that are stored and work that is performed, the results of which would not be available in finished construction until considerably later in the season.

In order to make the most of the limited labor supply, it is necessary that more attention than ever be given to labor-saving devices, and contractor's equipment should be as nicely balanced as possible, so that each operation will coördinate with all other operations that are required and not cause delay because one portion of the work is improperly or insufficiently equipped.

The whole situation is one that must be given very much closer study both on the part of the engineers and the contractors. Each must assume new responsibilities if road production is to be brought to a maximum.

Subgrade. — The employment of machinery makes possible refinements which otherwise would not be practicable. The preparation of the subgrade is an example in point. More study and care should be given this part of the work. I agree with those engineers who have expressed the opinion that the subgrade should receive little or no rolling. This is particularly true for heavy clay and gumbo soils. In general, it is recommended that the subgrade should be brought to within one or two inches of the desired elevation; the side forms should then be accurately set and the remaining portion of the subgrade carefully scraped or honed to the exact contour and elevation. This may be accomplished by a grading machine, recently put upon the market, which may be operated so as to bring the roadbed to as nearly true a surface as is desired for the surface of the concrete, which is as it should be.

On those subgrades, in clay soils particularly, where drainage is especially difficult, and upon certain types of heavy gumbo soils which undergo considerable change with the variations between dry and moist conditions, it is recommended that a

layer three or four inches thick, of cinders, sand, fine gravel or similar material, be placed, upon which the concrete is laid.

Broad, flat shoulders will help greatly to minimize movement in the subgrade due both to frost and moisture conditions. Narrow shoulders bordered by deep ditches is a condition to be avoided.

Side Forms. — The use of the subgrading machine which runs upon the side forms emphasizes the necessity for having them carefully placed and solidly constructed. If heavy steel forms, preferably what is known as a ship-angle shape, cannot be secured, then three- or four-inch wood forms are more to be desired than the lighter steel forms that have been used, and which have proved so ineffective.

Joints. — There is an increasing tendency on the part of many engineers to omit entirely expansion joints in the construction of concrete roads, and there has accumulated ample experience to justify such practice. The chief advantage gained by omitting expansion joints is the avoidance of an uneven surface at the joints, which often occurs unless extreme care is taken to place the joint and to finish the concrete surface in the immediate vicinity.

Reinforcement. — The use of larger units of reinforcement, spaced wider apart than has been the custom, is gaining some preference. Particularly has the employment of bars $\frac{3}{4}$ in. in diameter laid along the edge of the pavement and crosswise at intervals of four to five feet, proved to be a very practical and effective method. The use of reinforcement is strongly recommended for those portions of a road where the subgrade drainage is regarded as especially uncertain.

It is the practice in some localities to reinforce all the concrete in all of the roads laid, but it would seem to be a more effective use of the reinforcement if it were omitted over stretches of road which were well drained, and an additional amount, over that used at present, placed in those sections of the road where the greatest difficulty is expected, to obtain good subgrade conditions.

The amount of reinforcement that is used, and that it is practical to use from a cost standpoint, is not sufficient to add appreciably to the cross-breaking strength of a concrete slab.

It is absolutely erroneous, therefore, to consider that reinforcement in anywise replaces concrete and that a thinner slab may be laid with reinforcement than would be laid without it. If the amount of reinforcement were thirty or forty times as much as is customarily employed, there would be some basis for such a contention. Reinforcement is useful, not to prevent the formation of cracks, but to prevent a crack from opening and becoming of any appreciable size; and to this end a small amount of reinforcement is effective.

Coarse Aggregate Tests. — About one third of the state highway specifications for concrete roads prescribe that the coarse aggregate shall have a French coefficient of wear not less than a certain grade, the highest grade prescribed being 12, while other states admit as low as 6 or 7. The French coefficient of wear was designed, as all highway engineers know, to test materials for macadam roads. The effect of traffic on pieces of crushed stone in a macadam road is quite different from that upon pieces of crushed stone imbedded in a concrete road. In the former all the pieces are subjected to wear, — that is, due to the movement that occurs from the passage of a heavy vehicle, the pieces of stone move and rub upon one another, thus creating what is known as internal wear. It is essential, therefore, that pieces of rock having a high resistance to wear should be used, and, because of this, it was seldom advisable to use rock in a macadam road having a French coefficient less than 12 to 14.

But in the concrete road there is no internal wear, and therefore the French coefficient does not offer any criterion as to the adaptability of a given rock for concrete road work. There are many concrete roads which have been made of aggregate having a French coefficient as low as 7, subjected to very heavy traffic and showing after a number of years' service very little wear; no more than many other roads constructed with aggregate having much higher French coefficient of wear. In fact, it can be stated that as between an aggregate having a French coefficient of 7 and one having a coefficient two or three times as great there is no practical difference as to the wearing effect in a concrete road, and that, therefore, there is no reason to

exclude rock or pebbles that have a French coefficient as low as 6 or 7.

This point is discussed at some length by H. E. Breed, consulting engineer, New York City.*

Tests of Sand for Organic Impurities. — Too few specifications make provision for testing sand for organic impurities. The test is so simple and can be made so readily by any engineer or foreman in the field that it is entirely practical; and, because it is of the greatest importance that no organic impurities be in the sand, such tests should be required by all specifications.

The test is made by shaking a few ounces of the sand in a 3 per cent. solution of sodium hydroxide and, upon settlement over night, observing the clear liquid which, if colorless or at the most light yellow, indicates freedom of organic impurities; whereas if the liquid is a decided amber or brown it is an indication of an amount of organic impurity which should not be permitted in concrete for road purposes.

But a small amount of organic impurity is sufficient to reduce the strength of the concrete to a third or a quarter of what it would otherwise be. In fact, but a comparatively small amount of organic impurity is necessary to cause complete disintegration of the concrete.

It is oftentimes true that many sands apparently clean will contain organic impurities in sufficient amount to make them dangerous for use in concrete road work. Sands having organic impurities may be washed and in most instances most of the impurity removed, but they should be afterwards tested to make sure there does not remain a harmful quantity.

Consistency. — We have learned from the investigations of Prof. D. A. Abrams, of the Structural Materials Research Laboratory, Lewis Institute, Chicago, that the strength of concrete depends absolutely upon the ratio of the amount of water to the amount of cement, and that the use of more water than is necessary to produce a workable consistency or plasticity is merely wasting cement and producing concrete from one third to one half the strength that it would otherwise have. It is therefore important that our specifications should contain some

* *Municipal and County Engineering*, February, 1920, p. 5.

definite measure of the consistency desired. The majority of specifications at present merely describe the consistency of the concrete without providing any exact measure by which it may be ascertained.

The slump test using a truncated cone mold has been developed by F. L. Roman, testing engineer of the Illinois State Highway Department, which answers every purpose and may be readily used in the field. The method of making the test consists in filling a thin metal mold in the form of a truncated cone having an 8-in. base, 4-in. top and 12 in. high, with the freshly mixed concrete which is lightly tamped by a rod as the concrete is placed in the mold. As soon as the mold is filled and struck with a trowel it is removed by means of handles on either side, and the height of the concrete after removal of the mold is measured. The difference between this height and the height of the mold, or 12 ins., is taken as the slump. For concrete in concrete road work a practical consistency is obtained when the slump is between $\frac{1}{2}$ in. and 1 in. Less than $\frac{1}{2}$ in. gives too stiff a mixture, while more than 1 in. is unnecessarily wet if the road is to be finished by a mechanical tamping machine. Where the surface of the concrete is struck by a template worked by hand it may be necessary to use a consistency corresponding to a slump of $1\frac{1}{2}$ ins.

In practice, the application of the test will be to mix a batch of concrete, knowing the amount of water used, and make the slump test. Accordingly as the slump measured is too little or too great, more or less water will be used in the succeeding batches.

When the proper consistency has been obtained, as noted by the slump, there is little practical difficulty to secure a similar consistency by merely noting the appearance of the concrete. The consistency which gives the highest strength in the laboratory uses too dry a concrete for practical manipulation, and has a rather mealy-dry appearance; whereas the consistency containing the least amount of water which will give a workable plasticity, and therefore the strongest that can be made in actual work, is one which shows barely a glisten on the particles of the aggregate as they come out of the mixer. If the concrete has

an appearance wetter than this, the amount of water is unnecessarily large for practical handling in road work. If no more than 10 or 15 per cent. excess water is used, it has cut down the strength of the concrete by nearly 50 per cent. Too great attention cannot be paid to this important point of controlling nicely the amount of water used in mixing the concrete.

Proportions for Mixing Concrete. — Professor Abrams' investigations have also demonstrated that the effect of variation in the grading of the aggregate upon the strength of the concrete is due to the fact that one grading may require a different amount of water for a given amount of cement than is required for a different grading, to give in each instance the same workable plasticity. From the sieve analyses he has evolved a property of aggregates which he calls the " fineness modulus," which gives a measure of the relative grading of different aggregates. The fineness modulus, he finds, is such a property of the aggregate that two aggregates within reasonable limits of grading with the same fineness modulus will, if mixed with the same amount of cement and water, produce a concrete of similar plasticity, and will in a given time attain the same strength.

He has shown further, based upon the results of many thousands of tests, that, using the same proportion of cement with aggregates of different fineness moduli, and securing in each instance the same plasticity, the strength of the concrete varies as the fineness modulus of the aggregate.

The sieve analysis of a given aggregate being known, the fineness modulus can be computed; and we may then determine the proportion of cement to use to produce a concrete of the desired strength. Thus it is possible and practical to make concrete of equal strength of quite dissimilarly graded aggregates. For example, one aggregate may range from 3-in. pieces to the finer sand particles, while the second may contain no pieces over 1 in. in size. Yet, by varying the proportions of cement, each of these aggregates may be used and the strength of the resulting concrete be the same in each instance.

This fact is of great importance, as we are enabled to use a wide variety of aggregates with regard to sizes and grading. Many supplies of aggregates now excluded by the narrow re-

strictions of our specifications, may be employed and exactly as good concrete produced as that made under our present specifications. We have been somewhat inclined to develop a standard specification, and have lost sight of the fact that it is not the specification that is to be standard but, rather, the product. If concrete possessing the same strength and durability can be made from aggregates having various gradings and limiting sizes, then there is no reason to adhere to specifications which confine the selection of aggregates to those of a particular grading and exclude all others.

Until we had before us the results of the investigations of Professor Abrams, we could not have said with any precision just what difference should be made in the proportioning of aggregates of different sizes in order to produce concrete of a given strength. This we are now able to accomplish; but it is not necessary here to enter into a further discussion of the principles involved. For those who desire to study the matter more thoroughly, reference may be made to the bulletins of the Structural Materials Research Laboratory, Lewis Institute, Chicago, particularly Bulletin No. 1.

Under our standard specifications to-day for fine aggregate, we are limited to the use of material varying from $\frac{1}{4}$-in. size particles down to the finer materials, specifying that it shall be reasonably well graded between the smaller and larger particles. Suppose, however, there is available a quantity of sand containing no particles larger than $\frac{1}{8}$-in., or possibly containing no particles over 1/14-in., are we to throw away these sands, or may we use them varying the proportions so as to produce the same strength concrete as obtained with the sand containing $\frac{1}{4}$-in. particles?

Our specifications to-day for coarse aggregate, while they vary somewhat more than for fine aggregate, yet restrict the choice of materials to very narrow limits, the sizes usually specified varying from $\frac{1}{4}$-in. particles to 2 in., some as high as 3-in. and a number limiting the larger size to $1\frac{1}{2}$ ins. But we have at hand, let us say, a large amount of material which contains no particles less than 1 in. in size, varying from that to 2 ins. or possibly to 3 ins., or there is other material available

Abrams' Table of Proportions and Quantities for One Cubic Yard of Concrete.

Based upon laboratory investigations, using approved materials, compressive strength, twenty-eight days, with workable plasticity, 6- by 12-inch cylinders, 3 000 pounds per square inch.

Sizes.		Fine Aggregates. Screen Openings Per Inch.														
		0-28			0-14			0-8			0-4			0-¾ in.		
Coarse Aggregates Inches.	Cement in Barrels Aggregates in Cubic Yards.	Cement	Fine	Coarse	Cement	Fine	Coarse	Cement	Fine	Coarse	Cement	Fine	Coarse	Cement	Fine	Coarse
No. 4 Screen to ¾	Proportions	1	1.3	2.4	1	1.6	2.4	1	1.8	2.3	1	2.0	2.3	1	2.7	1.5
	Quantities	1.96	.37	.69	1.85	.44	.66	1.82	.48	.62	1.75	.52	.59	1.79	.72	.40
No. 4 Screen to 1	Proportions	1	1.3	2.7	1	1.6	2.6	1	1.8	2.6	1	2.0	2.5	1	2.6	1.8
	Quantities	1.90	.36	.76	1.77	.42	.68	1.72	.46	.66	1.67	.50	.62	1.72	.66	.46
No. 4 Screen to 1½	Proportions	1	1.2	3.1	1	1.6	3.2	1	1.7	3.1	1	2	3	1	2.4	2.4
	Quantities	1.82	.32	.84	1.68	.40	.79	1.63	.41	.75	1.61	.47	.72	1.62	.57	.57
No. 4 Screen to 2	Proportions	1	1.2	3.5	1	1.5	3.5	1	1.6	3.7	1	1.9	3.6	1	2.2	3.1
	Quantities	1.75	.31	.90	1.63	.36	.85	1.55	.36	.85	1.52	.43	.81	1.53	.50	.70
No. 4 Screen to 2½	Proportions	1	1.1	3.8	1	1.4	3.9	1	1.6	4.0	1	1.8	4.0	1	2.1	3.5
	Quantities	1.72	.28	.97	1.58	.33	.91	.51	.35	.89	1.49	.40	.88	1.50	.46	.78
No. 4 Screen to 3	Proportions	1	1.1	3.9	1	1.4	4.1	1	1.5	4.1	1	1.7	4.1	1	2.0	3.7
	Quantities	1.69	.28	.97	1.58	.33	.97	1.49	.33	.90	1.49	.37	.90	1.49	.44	.81
¾ to ¾	Proportions	1	1.3	2.3	1	1.7	2.3	1	1.9	2.3	1	2.2	2.2	1	2.8	1.4
	Quantities	1.96	.37	.67	1.85	.46	.63	1.82	.51	.62	1.75	.57	.57	1.79	.75	.37
¾ to 1	Proportions	1	1.3	2.6	1	1.7	2.6	1	1.9	2.5	1	2.2	2.4	1	2.7	1.7
	Quantities	1.90	.36	.74	1.77	.44	.68	1.72	.48	.64	1.67	.54	.59	1.72	.68	.43
¾ to 1½	Proportions	1	1.3	3.0	1	1.7	3.0	1	1.9	3.0	1	2.1	2.9	1	2.6	2.2
	Quantities	1.82	.35	.80	1.68	.43	.75	1.63	.46	.73	1.61	.50	.68	1.62	.63	.53
¾ to 2	Proportions	1	1.3	3.3	1	1.7	3.4	1	1.8	3.5	1	2.0	3.4	1	2.4	2.9
	Quantities	1.75	.34	.86	1.63	.41	.83	1.55	.42	.80	1.52	.45	.77	1.53	.62	.66
¾ to 2½	Proportions	1	1.3	3.7	1	1.6	3.7	1	1.7	3.9	1	2.0	3.8	1	2.3	3.3
	Quantities	1.72	.33	.95	1.58	.37	.87	1.51	.37	.87	1.49	.44	.84	1.50	.51	.74
¾ to 3	Proportions	1	1.2	3.8	1	1.6	3.9	1	1.7	4.0	1	1.9	4.0	1	2.2	3.5
	Quantities	1.68	.30	.95	1.58	.37	.91	1.49	.37	.88	1.49	.42	.88	1.49	.48	.77
½ to ¾	Proportions	1	1.5	2.3	1	1.9	2.2	1	2.1	2.2	1	2.3	2.1	1	2.8	1.3
	Quantities	1.96	.44	.67	1.85	.52	.61	1.82	.56	.59	1.75	.59	.54	1.79	.75	.34
½ to 1	Proportions	1	1.5	2.5	1	1.9	2.5	1	2.1	2.4	1	2.3	2.4	1	2.8	1.6
	Quantities	1.90	.42	.70	1.77	.50	.66	1.72	.53	.61	1.67	.57	.59	1.72	.72	.41
½ to 1½	Proportions	1	1.4	2.8	1	1.9	2.9	1	2.1	2.9	1	2.2	2.8	1	2.7	2.1
	Quantities	1.82	.37	.75	1.68	.47	.73	1.63	.51	.69	1.61	.52	.66	1.62	.65	.51
½ to 2	Proportions	1	1.4	3.3	1	1.9	3.3	1	2.0	3.4	1	2.2	3.3	1	2.7	2.7
	Quantities	1.75	.36	.86	1.63	.46	.79	1.55	.46	.78	1.52	.50	.74	1.53	.62	.62
½ to 2½	Proportions	1	1.4	3.6	1	1.8	3.6	1	1.9	3.7	1	2.1	3.7	1	2.6	3.1
	Quantities	1.72	.35	.91	1.58	.43	.85	1.51	.42	.83	1.49	.46	.81	1.50	.57	.69
½ to 3	Proportions	1	1.3	3.7	1	1.8	3.8	1	1.8	3.9	1	2.1	4.0	1	2.4	3.3
	Quantities	1.68	.33	.92	1.58	.42	.89	1.49	.40	.86	1.49	.46	.88	1.49	.53	.63
¾ to 1	Proportions	1	1.7	2.4	1	2.1	2.4	1	2.4	2.1	1	2.6	2.2	1	3.1	1.5
	Quantities	1.90	.48	.68	1.77	.55	.63	1.72	.61	.53	1.67	.64	.55	1.72	.79	.39
¾ to 1½	Proportions	1	1.7	2.7	1	2.0	2.8	1	2.3	2.7	1	2.5	2.7	1	3.0	2.0
	Quantities	1.82	.46	.73	1.79	.50	.70	1.63	.55	.65	1.61	.59	.64	1.62	.73	.48
¾ to 2	Proportions	1	1.7	3.1	1	2.0	3.1	1	2.3	3.1	1	2.5	3.0	1	3.0	2.4
	Quantities	1.75	.44	.80	1.63	.48	.75	1.55	.53	.72	1.52	.56	.67	1.53	.68	.55
¾ to 2½	Proportions	1	1.7	3.3	1	2.0	3.5	1	2.3	3.4	1	2.4	3.4	1	2.9	2.8
	Quantities	1.72	.43	.84	1.63	.47	.83	1.51	.52	.76	1.49	.53	.75	1.50	.64	.62
¾ to 3	Proportions	1	1.7	3.5	1	2.0	3.7	1	2.3	3.7	1	2.4	3.6	1	2.8	3.1
	Quantities	1.68	.43	.88	1.58	.47	.87	1.49	.51	.81	1.49	.53	.79	1.49	.62	.68
1 to 1½	Proportions	1	1.7	2.8	1	2.0	2.9	1	2.3	2.7	1	2.6	2.6	1	3.1	2.0
	Quantities	1.82	.46	.75	1.68	.50	.73	1.63	.55	.65	1.61	.62	.62	1.62	.75	.48
1 to 2	Proportions	1	1.5	3.2	1	1.9	3.5	1	2.2	3.3	1	2.4	3.3	1	3.0	2.6
	Quantities	1.75	.39	.83	1.63	.46	.85	1.58	.51	.76	1.52	.54	.74	1.53	.68	.59
1 to 2½	Proportions	1	1.4	3.4	1	1.9	3.8	1	2.0	3.7	1	2.3	3.7	1	2.7	3.1
	Quantities	1.72	.35	.86	1.58	.45	.89	1.51	.44	.83	1.49	.51	.81	1.50	.59	.69
1 to 3	Proportions	1	1.3	3.6	1	1.8	4.0	1	2.0	3.9	1	2.2	3.9	1	2.7	3.3
	Quantities	1.67	.33	.90	1.58	.42	.94	1.49	.44	.86	1.49	.48	.86	1.49	.59	.73

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containing nothing less than $\frac{1}{2}$-in., and perhaps nothing over 1 in. The question is, can we use such aggregates which vary so widely from our present specifications in such a way as to produce concrete as strong and durable as with the aggregates that comply with our present specifications? From the discussion that has been made of Abrams' work we know the answer to be "yes."

Professor Abrams has prepared a table, which puts the results in a practically available form.

The basis upon which this table has been constructed is the production of a concrete that experience has shown will have sufficient strength and durability for its purpose. There have been many miles of concrete roads built using a 1 : 2 : 3 mixture, with the fine aggregate varying from $\frac{1}{4}$-in. size material to the finer particles, and the coarse aggregate varying from $\frac{1}{4}$-in. material to $1\frac{1}{2}$- or 2-in. size pieces. Such a concrete tested under laboratory conditions, using 6 by 12-in. cylindrical test specimens and with a plasticity that secures a practical workability, gives very closely, at twenty-eight days, a compressive strength of 3 000 lbs. per sq. in. This was taken as a basis upon which the table has been prepared.

Five different fine aggregates were selected, varying, as the table will indicate, from the finest which contains no particles over 1/28 in. and others not over 1/14, $\frac{1}{8}$, $\frac{1}{4}$ and $\frac{3}{8}$ ins. in size, respectively. A wide selection of coarse aggregates is given, beginning with the first group which has the smaller limit of size at $\frac{1}{4}$ in., while the larger limit varies from $\frac{3}{4}$-in. to 3 ins. In the second group the lower limit for the coarse aggregate is $\frac{3}{8}$ in., with sizes for the upper limit varying from $\frac{3}{4}$ in. to 3 ins. Similarly, there are groups with the lower limit at $\frac{1}{2}$ in., $\frac{3}{4}$ in. and 1 in., respectively, the upper limits in each group varying in sizes to 3 ins., making in all 27 variously sized coarse aggregates; each in turn combined with 5 different fine aggregates or sands, thus making 135 combinations of fine and coarse aggregates, each of which is proportioned so as to produce, under practical working conditions as to consistency, the same strength concrete. In all cases it is to be assumed that all aggregates that are to be used, irrespective of size or grading, are to be of

material structurally sound, clean and free of organic impurities.

It should be mentioned that Professor Abrams' tests demonstrated that the resistance to abrasion of concretes varied as the compression strength, — the greater the strength, the greater the resistance to wear; and that concretes of equal crushing strength gave about equal resistance to abrasion.

In the practical application of the table we first have to define how to determine what is the upper limit of size for a given aggregate. Should any sand containing a few $\frac{1}{4}$-in. particles be classed as one varying from zero to $\frac{1}{4}$ in., or should there be required a certain percentage of material between the $\frac{1}{4}$-in. size and the next lower limit, as shown in the table, which is $\frac{1}{8}$-in? The proper allowance, Professor Abrams tells us, should be 15 per cent.; that is, a fine aggregate with $\frac{1}{4}$-in. particles which did not contain 15 per cent. by volume of the material passing the sieve with 4 openings to the inch and retained on a sieve with 8 openings to the inch, should be classed as $\frac{1}{8}$-in. sand and not as $\frac{1}{4}$ in.

The following rule is to be applied to determine the limits of sizes for the coarse aggregate: There shall be not less than 10 per cent. of material between the largest size and the next smaller size shown in the table. Thus a coarse aggregate to be classed as $2\frac{1}{2}$-in. size shall have not less than 10 per cent. of the material between the $2\frac{1}{2}$-in. size and the 2-in. size. If there is less than 10 per cent. between the $2\frac{1}{2}$-in. size and the 2-in. size it should be classed as 2-in. provided there should be at least 10 per cent. of the material retained upon the $1\frac{1}{2}$-in. screen.

The lower limit of size of a coarse aggregate shall be the largest size shown in the table for coarse aggregate, below which there is not to exceed 10 per cent. by volume of the material. Thus a coarse aggregate in which the lower limit of size is to be 1 in. should be an aggregate in which there is not to exceed 10 per cent. by volume of the material passing the 1-in. screen. In all coarse aggregates, if there is to exceed 5 per cent. of the volume passing a $\frac{1}{4}$-in. sieve, then such excess shall be considered as fine aggregate, and the amount of fine aggregate to be used is to be modified accordingly.

It will be noted that, in addition to the proportions by which

to combine the various fine and coarse aggregates with the unit quantity of cement, there is also given the quantities of the materials to be used to make 1 cu. yd. of concrete. These quantities are given in barrels and hundredths of barrels for cement, and in hundredths of cubic yards for the fine and coarse aggregates. The quantities shown do not make any allowance for waste from any source; so that for practical estimates they should be increased from the amounts shown, as experience in handling the work according to the particular method to be employed has indicated as necessary.

The following example will make clear the practical use of the table:

It will be supposed that one sand is that usually specified, from $\frac{1}{4}$-in. down, and must be shipped in at a cost of $2 per cu. yd., and that one coarse aggregate, varying from $\frac{1}{4}$-in. to 2 ins., must also be shipped in at a total cost of $3 per cu. yd.; that there is available locally a supply of sand and coarse aggregate, each being rather fine, the sand varying from $\frac{1}{8}$-in. down, which costs $1.50 per cu. yd., while the coarse aggregate varies from $\frac{1}{4}$-in. to 1 in. and may be secured at a cost of $2.50 per cu. yd. The cement in each case is assumed to cost $3 per barrel. The cost of a cubic yard of concrete using the materials to be shipped in would then be as follows:

1.52 barrels cement	@	$3.00	=	$4.56
.43 cu. yds. of sand	@	2.00	=	.86
.81 cu. yds. of coarse aggregate	@	3.00	=	2.43
Total cost of materials for 1 cu. yd. concrete				$7.85

Using local materials the cost would be:

1.72 barrels cement	@	$3.00	=	$5.16
.46 cu. yds. of sand	@	1.50	=	.69
.66 cu. yds. of coarse aggregate	@	2.50	=	1.65
Total cost of materials for 1 cu. yd. concrete				$7.50

In this instance the local aggregate, although fine and requiring more cement, will produce a yard of concrete at less cost. In general, it will be found that the use of finer sand or of

finer aggregate increases the amount of cement, the opposite being true for coarser sizes. Thus a coarse aggregate, with all of the fine material removed, varying from 1 in. to 3 in. in size, combined with sand varying from $\frac{1}{4}$-in. down, uses 1.49 barrels of cement; whereas an aggregate varying from 1 in. to $\frac{1}{4}$ in. combined with the same sand, $\frac{1}{4}$ in. down, requires 1.67 barrels of cement for a cubic yard of concrete.

If the producer of aggregate materials can say what are the sizes of aggregates he can furnish, they can be used to make a concrete of a given strength. Should concrete of a strength other than 3 000 lbs. per sq. in. be desired, then another table would be calculated with the proportions and quantities required accordingly; but the table given here is confined to the use of concrete for concrete roads where a better quality and greater strength are required than is necessary for concrete for many other structures.

A specification to include this table would provide a section somewhat as follows:

Specifications for Proportions Using Abrams' Table. — The proportions of cement, fine and coarse aggregate, for the concrete shall vary according to the sizes of the fine and coarse aggregates to be used, as indicated in Abrams' Table of Proportions and Quantities as printed herewith. One sack of cement is to be considered as 1 cu. ft., and proportions are to be by volume. The quantity of cement in a cubic yard of concrete in place shall be not less than the amount as shown in the table for a given proportion of coarse and fine aggregates.

Before work is started the contractor shall advise the engineer of the particular sizes of fine and coarse aggregates he expects to use, and no change shall be made by the contractor from such sizes except upon due notice in writing to the engineer.

To determine in what classification a given aggregate shall fall, the following method shall prevail:

For fine aggregate there shall be not less than 15 per cent. of the total volume between the coarsest size and the next smaller size shown in the table. Thus, if fine aggregate is to be classed as $\frac{1}{4}$-in., there shall be not less than 15 per cent. of the material between the No. 4 screen and the No. 8 screen.

In coarse aggregate there shall be not less than 10 per cent. of material between the largest size and the next smaller size shown in the table. Thus, a coarse aggregate to be classed as $2\frac{1}{2}$-in. size shall have not less than 10 per cent. of the material between the $2\frac{1}{2}$-in. size and the 2-in. size.

In each instance, whether fine or coarse aggregate, if there is not of the coarser sizes the amounts as here described, the upper limit of size of the material is to be that of the next smaller size. That is, an aggregate that contains some $2\frac{1}{2}$-in. material, but less than 10 per cent. between $2\frac{1}{2}$-in. and 2-in., is to be classed as 2-in. size for the upper limit.

The lower limit of size of a coarse aggregate shall be the size shown in the table for coarse aggregate below which there is not to exceed 10 per cent. by volume of the material.

If there is to exceed 5 per cent. of the volume of coarse aggregate passing the No. 4 sieve then such excess shall be considered as fine aggregate and the amount of fine aggregate to be used shall be modified accordingly.

Aggregate falling between limits of sizes other than shown by the table may be used only upon special written permission of the engineer and in such proportions as he may indicate.

In all cases aggregates both fine and coarse are presumed to be reasonably well graded between the limits specified.

Specifications for Consistency. — The amount of water to be used for mixing concrete shall be that which will give a consistency to be determined as follows:

Newly mixed concrete shall be placed in a truncated-cone shaped metal mold having an 8-in. base, 4-in. top and 12 ins. high. The concrete shall be lightly tamped with a rod as it is placed in the mold, which when filled is to be immediately removed by means of handles on either side of the mold and the slump or settlement of the concrete noted. For concrete to be finished by a mechanical tamping machine, the slump shall not be less than $\frac{1}{2}$-in. nor to exceed 1 in. If the concrete is to be finished by hand methods, the slump may be as much as $1\frac{1}{2}$ ins.

DISCUSSION.

ARTHUR W. DEAN.* — Mr. Johnson's table that he has given is most impressive. Theoretically, I think you will agree with me it doesn't look quite right. Nevertheless, if it has been proven by experiment, it must be considered as being correct.

Mr. Johnson did not cover some matters that may appear small but nevertheless are important; he stated that he should not cover every detail because he expects to have them brought out in the discussions.

First is the matter of foundations. There seems to be, in the minds of some road builders, a tendency to believe that if you have such a solid surface as cement concrete you do not need as much foundation, or as solid a foundation, or a foundation as free from water, as you do if you are building waterbound or bituminous macadam or other similar surface that has more or less elasticity. It has been pretty well demonstrated in practice, however, that you need just as much and as good a foundation and just as much underdrainage for taking care of the subsoil water for a cement concrete surface as you do for any other type of surface.

Some six years ago, if I may bring up a local matter, the Massachusetts Highway Commission was about to build a section of state highway in North Andover. An estimate was made, using about 18 ins. of foundation, under 6 ins. of bituminous macadam. The cost ran up to somewhere in the vicinity of $30 000 a mile, according to that estimate. It was argued that if a concrete surface were used, less foundation and drainage would be necessary, and the cost of concrete surface with alleged sufficient foundation would be less than the cost of bituminous macadam with its necessary foundation. Consequently, what the engineers of the Commission called a "demonstration road," and some others called an "experimental road," was built. Those of you who travel around the country in automobiles, and have been over the road from Lawrence to Salem, may have noticed a mile and a half of road built without much foun-

* Chief Engineer, Division of Highways, Department of Public Works, State House, Boston, Mass.

dation or much drainage, and that road, originally in 30 ft. slabs, is now in slabs from 30 ft. down to slabs of 1 ft. square. The slabs are all there, however. Very little maintenance has been necessary, except to fill the cracks with tar or asphalt, and there has been very little time in the spring of the year when the road is not fairly smooth to drive over. No slabs have had to be entirely rebuilt, but two or three have been partially rebuilt since the road was constructed. Other maintenance was simply to putty up the cracks. While the expense of maintenance has not been large, the method of construction is inadvisable, and the cracks make the surface unsightly. Its designation by the engineers as a "demonstration road" originated at the time it was built, it being their belief that the construction was improper, and the appearance of the road surface surely demonstrates the truth of their belief.

Mr. Johnson spoke of the necessity for reinforcement, or, rather, usefulness of it. A portion of that road was built with reinforcement in certain sections, taking sections 100 to 150 ft. long, at various points along the road, in order to get a good comparison between the sections which had been reinforced and those without. An inspection of the road will show that where the reinforcement exists there is a little difference in the size of the cracks; but there are just as many cracks where it was reinforced as there are where it was not reinforced in the adjoining sections. My theory of reinforcement is that it may be excellent for a few years, in keeping the cracks from being quite as wide as if there were no reinforcement, but I think all engineers will agree with me that, with wire-mesh reinforcement, when a crack comes the moisture will get in, and it will not be many years before the wire mesh at that point has rusted out, and then where the crack is there will be no reinforcement. When frost is coming out of the ground or going into the ground, the ground does not rise uniformly, and if your reinforcement is to keep your concrete from cracking, due to loading of the concrete, you don't know whether to provide beam or cantilever. If the reinforcement is placed at the bottom of the concrete you assume you are taking care of it when the load is on the center; but the edges may not be well held up. On the other hand, the center may be

held up and not the edges. Reinforcement really appears of no value except to temporarily keep the cracks from spreading.

Mr. Johnson spoke of joints. It has been my observation of these concrete surfaces, that where expansion or contraction joints are placed 30 ft. apart, other additional cracks form in the concrete slabs. Where they are placed 120 ft. apart you have just about the same number of cracks in a 120 ft. single slab as you have in four 30-ft. slabs. Personally, I can see absolutely no advantage of putting in expansion joints, other than what might be put in at the end of a day's work, or a half day's work (the day's work being assumed at 250 to 300 lin. ft.). No matter how carefully you put in these expansion joints you can't avoid a little disagreeable motion when you ride over them with a rubber-tired vehicle. When you ride over a joint that is made by nature, on the other hand, there is not the ridge, depression, or difference in elevation; consequently the road rides smoothly. Hence I should advocate no expansion joints, except, as I said, at the end of a day's work, but let nature make her own joints, because you know she will make them, even if you make artificial ones for her.

Mr. E. S. Larned.* — I want to ask a question in regard to this sand which Professor Abrams used in preparation for this tabulation. In the sizes running from a No. 28 mesh sieve to a $\frac{3}{8}$-in. sieve, is that natural sand or artificially graded sand?

Mr. Johnson. — It is understood that 0 to $\frac{3}{8}$-in. sand means sand that is graded from the finest material to $\frac{3}{8}$-in. size.

I cannot say positively whether the samples that may have been used were specially prepared or not. It is evident that sands varying from finest particles to $\frac{3}{8}$-in. in size may have a variety of gradings, some of which may have the same fineness modulus, while others will vary. These tables are based upon what might be termed an average fineness modulus, that is, the fineness modulus of average grading of material for the particular limits of size shown. Theoretically, if the fineness modulus varied from the one assumed, then the proportions should also be varied, but practically it is not found necessary to make such fine distinctions. It is hardly likely that there would be a

* Civil Engineer, 79 Milk St., Boston, Mass.

material with the sizes indicated and having the percentages of fine and coarse as prescribed which would have a fineness modulus differing from the one assumed in the construction of the tables sufficient to make necessary any variations in the proportions.

Mr. Larned. — I don't know what the impression generally might be, which has been conveyed by these figures, but in a way, if I take Mr. Johnson's statement as made, it upsets some pretty well-established opinions we have formed in regard to sand. I can't think that Mr. Johnson means that we shall refer to the bank sand man, or contractor, and learning what he has that we can use it by referring to this table, because a great many sands are absolutely unfit for concrete work, even though they might conform, in a measure, to these granulometric compositions. Sand that runs from zero to No. 28 mesh is a very fine sand. It would naturally produce a weak mortar; and how, with a sample of that sand, you can obtain strength equal to that with the $\frac{1}{4}$-in. sand, and in addition to that use a larger proportion of sand, simply by using a coarser large aggregate, and obtain equal strength, I don't understand.

Of course I fully appreciate the value of these experiments, and I think it is furnishing data of great interest and value to the profession. I do think, however, that when we come to concrete-road construction we are confronted with conditions so far different from laboratory results that we have to consider some other things, and I think if the local sand is tested in the laboratory, in the only way we now have for a basis of comparison, — with standard sand, — Ottawa sand (I think this is a pretty good basis on which to work), — that with all the various combinations that have been worked out, with the various aggregates, fine and coarse, in a practical way, we have come down to a pretty general specification where we can use either a 1 : $1\frac{1}{2}$: 3 mix or a 1 : 2 : 3 mix, if we want a pretty fat concrete; and if it is possible to vary these results in the interest of economy, of course that is desirable, but I think the use of sand itself should be based not alone on its fineness but on the grade of sand to be used with particular reference to its effect upon the early strength of concrete.

Referring to the question of joints, I find a general recognition of the unimportance of contraction joints. I have long regarded them as not only unnecessary, but as a defacement and an element of weakness in a concrete road. As generally constructed, with fabricated mastic or three layers of three-ply paper, which must stand up above the surface of the concrete, this necessitates a split float. The concrete must be brought up to that bulkhead, and in doing so, with concrete of a normally wet consistency, an excessive amount of fine material is brought against the joint line. There is, consequently, more subsidence at that point, due to excessive wetness and fineness, which brings about unevenness; and then, when the jointing material gives out, an open joint from $\frac{3}{8}$ in. to $\frac{3}{4}$ in. develops, which is a weakness, because every time a wheel drops into it the concrete chips off, and then it opens up even wider.

In the matter of finishing concrete, I thoroughly approve of the use of the roller and of the belt. This possesses all the advantages Mr. Johnson has outlined, and is economical to the contractor. He can do the work better and cheaper in that way. There is a knack, however, in the use of the roller. It can't be put on the work too soon, and you can't follow up with the belt too soon. You must wait until the work is just the right consistency to admit of the belt slipping readily, and yet not working too deep into the concrete.

Foundations are one of the most important things, and I am glad to hear that Mr. Johnson emphasizes the necessity of a uniform base. It is a very common thing to-day, in the construction of concrete slabs, to see them put on an earth or gravel road, or on worn-out bituminous macadam. If the road is not too badly worn out, they spend very little time over the base, other than to fill up the irregularities and spread a very light fill on the sides of the road. The crown of the road often is not taken out. I believe that there is danger in this. In Delaware, of course, the soil is different. It runs from clay to fine sand and they use this screeding apparatus, which shaves off the base, is pulled ahead, and with rolling gives a very flat, true surface. I believe that is very desirable. In Massachusetts to-day some engineers are looking with favor upon the use of

the sand cushion between the concrete slab and the foundation, whatever it may be, — earth, stone, gravel, or clayey soil. I believe this is a very excellent thing. I think a sand cushion of as little as 1 in. will do away with much of the trouble by frost and moisture action.

I think the question of protecting the surface of the concrete against too rapid drying out is a good thing to consider. I have noticed that too often the specifications are drawn for canvas covers, and then canvas covers are not used. It has been found, if the slab is covered promptly and the covering wetted down promptly, that you get very excellent results. A few years ago I became an amateur contractor. I used for covering purposes a fine material, stone dust, that we later put in the shoulder of the road. We had very satisfactory results. We got no crazing or checking, and I don't believe the results would have been any better with canvas covers, and if we had been forced to use canvas it would have added very materially to the cost of the work.

I think those things should be very carefully considered as reducing the cost of the work. It is very important to keep the cost down to the contractor, and thus, through him, to the municipality.

Mr. Johnson. — I might say a word in addition to Mr. Larned's discussion. This idea that we have, that concrete is made up of mortar and coarse aggregate, is absolutely wrong, if we are going to get the essence of the work of Professor Abrams. Concrete is a mass of aggregates — they may be all of them fine or two of them fine, or anything. The object of the division into fine and coarse is simply to make the thing commercially practicable. Now, it would be better for concrete to have four divisions and thus have better control of the aggregate, and we would then know more nearly, with any given aggregate, just how much of the aggregate we should use. The comparison of sand with Ottawa sand has no significance whatever. The point is, does the sand that we use, with the rock that we have, produce the concrete that we want? And, if we can show that it does, any other comparison is aside from the matter, or useless. I can't give you the basis of all of this work. It would take too

long, if I could. But the bulletins Professor Abrams has issued contain the principal portion of it, and if any of you are interested in it they are available and have been republished by the technical press.

In the matter of durability we are assuming that we have good concrete, and hence we can forget the action of traffic on that concrete. Durability depends on climatic action, — movement of the subgrade resulting in cracks. Those are the elements that will determine the life of the road, and not the wear due to traffic. That has been slight, even on roads carrying the heaviest traffic.

MEMOIR OF DECEASED MEMBER.

HENRY MANLEY.*

HENRY MANLEY was born in what was then North Bridgewater and is now Brockton, Mass., on August 31, 1841, and died



HENRY MANLEY

October 28, 1919, at his home in West Roxbury. His father was Salmon Manley, a substantial farmer, and his mother was Iza

* Memoir prepared by C. Frank Allen Edward W. Howe and Laurence B. Manley.

Annette Howard. Through his father's mother he could trace his descent from Francis Cooke, one of the *Mayflower* passengers, and again, through his own mother, he was descended from Mary Chilton, who is reputed to have been the first woman from the *Mayflower* to alight on Plymouth Rock.

Among the earliest of his ancestors known to have settled in the Old Colony, was John Howard who came from England, at the age of fifteen, and lived in the family of Miles Standish in Duxbury. The records show him as "able to bear arms" in 1643. When, in 1649, Miles Standish and two others bought from the Indians the site of Bridgewater under authorization from the Old Colony Court at Plymouth, this John Howard became one of the original proprietors of Bridgewater. He was evidently a man of prominence, one of the earliest surveyors of highways, a selectman in 1678, and later, in 1683, a representative to the General Court. At his death he was possessed of 450 acres of land in Bridgewater.

The first Manley of whom a record is extant was William Manley, who left Weymouth to settle in Easton about 1695. Early in the next century his grandson, Daniel, the great-grandfather of Henry Manley, removed to the farm in North Bridgewater, where Henry Manley was born. This farm, with some additions, remained in the family for nearly two hundred years, until it was taken by the City of Brockton for its sewage disposal beds. All the Manleys were farmers of substance and standing in the community and signed themselves "yeomen." They were evidently well educated; the second Daniel Manley, grandfather of the subject of this memoir, was evidently of this type, as many of his accounts and records, written in a beautiful hand, are preserved in the family.

It has frequently been stated that the best crops of New England have been its men; and its best fruits, character. The residents of the Old Colony, from its earliest settlements, have been among those to whom is due, in large measure, the leadership which the Commonwealth of Massachusetts early exerted in religion, education and industry.

It was Henry Manley's good fortune to be born and brought up on a New England farm, an unrivaled school for the develop-

ment of industry, resourcefulness and self-reliance. In so far as engineering consists of providing suitable means for meeting existing conditions, a farm offers opportunity for the development of engineering qualities.

The early education of young Manley differed little from that of other boys. He stood well in the "district school" characteristic of his time. Even then, note was taken of the originality of thought so characteristic of him. When he was eleven years old, his father died as the result of an accident. Farm work under his older brothers proved more irksome to him than while his father was living. A fondness for learning led him, at the age of sixteen, to apply for entrance to the State Normal School at Bridgewater, but it was found that he was a year too young. The outcome was that he attended Bridgewater Academy for a year. Here he met the principal's son, Francis T. Crafts, who became his lifelong friend, his army chum and companion in his later travels. Manley then entered the Normal School, from which he was graduated in 1860. Following this, he spent about two years in teaching.

When the Civil War came on, Henry Manley, at the age of twenty-one, enlisted in Company K of the Third Massachusetts Volunteer Militia, being mustered in on September 23, 1862, and mustered out on June 26, 1863. His father had served for a time in the War of 1812. Three of his ancestors were in the Colonial militia during the American Revolution. The regiment saw service in North Carolina, in the battles of Kingston, Whitehall and Goldsborough. It did not see excessively bloody service, but the long marches and the southern climate seriously affected Manley's health, so that with his friend Crafts he took a long sea voyage, landing at Cape Town, South Africa. At Port Elizabeth, and later at Uitenhage, they engaged in a photographic business. A fire finally put a stop to this, and led to his leaving South Africa after spending about a year there.

Mr. Manley returned to take up teaching again for a time, but he had decided to become a civil engineer, and, in 1866, he entered the office of J. Herbert Shedd, in Barrister's Hall, Court Square, Boston, a site now occupied by Young's Hotel. This office was, perhaps, the most important in the city at that

time, and offered the best training for prospective engineers. An " apprentice " system was then in force, the pay scheme being one dollar per day for the first year; one dollar and a half the second; two dollars for the third year. This payment per day was for ten hours, provided one had work. There was a " tuition " charge of one hundred dollars per year whether there was work or not. Many well-known engineers had their training, in whole or in part, in this office. While connected with Shedd's office, Manley went to Providence upon the preliminary survey for the water works, of which J. Herbert Shedd later became chief engineer.

During his stay in this office he was loaned for a time to the city engineer of Boston. The outcome was that in the spring of 1869 he was permanently transferred to the office of the city engineer of Boston and remained in that service until his retirement, forty-two years later.

His earliest work of importance with the City of Boston was making surveys for supplying water to Roxbury and Dorchester, both of which had recently been annexed to Boston; and later came surveys for the extension of the water service to Deer Island.

He made surveys for, and had charge of the construction of the sea walls on Atlantic Avenue, from Broad Street to Commercial Street at Eastern Avenue, and also had charge of construction of numerous wharves and bridges, among them the Federal Street Bridge to South Boston, the Chelsea Street Bridge from East Boston to Chelsea, the bridge on the extension of Congress Street to South Boston, and the rebuilding of the Broadway Bridge across Fort Point Channel.

In 1873, when Joseph P. Davis became city engineer, he assigned Manley to the work of surveys and examinations of all the bridges within the city limits. This included making plans of many bridges of which there had been no record in the office. In 1877, he was assigned to the examination and repairs of the bridges of the city, and continued in that work until 1891.

Following an act of the legislature providing that a large proportion of the cost of street construction should be assessed upon the abutting property, an extensive program of street im-

provement was entered upon, and it fell to the engineering department to take care of the surveys, preparation of plans and specifications, together with supervision of construction. Manley was put in charge of this work in 1891, and continued to be connected with it until his retirement in 1910. He was retired with a pension under a city ordinance applying particularly to veterans of the Civil War. During his connection with the City he found opportunity for more or less private practice in various parts of New England.

Mr. Manley was one of the group that started a society of civil engineers in Boston in May, 1873, and was elected one of the vice-presidents of that society. When it appeared, after a few meetings had been held, that there already existed, although then dormant, "The Boston Society of Civil Engineers," chartered in 1851, he was one of a committee of inquiry into the situation. The outcome was a revival of the old society, the members of which met and took into their society all those who had become members of the new society; this was in June, 1874.

He was treasurer of the Boston Society of Civil Engineers from 1880 to 1892, when he was elected president. He was also elected a director for two years, immediately following his presidency. For twenty-six consecutive years Manley was each year elected by general consent "the committee" to arrange for the annual dinner. This extended from the first annual dinner, in 1883 up to and including 1908, after which a new scheme for the annual meeting and smoker at the City Club brought about a new order of things. His election to the presidency by a large majority, at a time when three nominations were necessary, was an evidence of his popularity and an appreciation of his long and efficient service to the Society.

Of several papers before the Boston Society of Civil Engineers, the most interesting and important was that on "Rapid Transit in Boston," presented in 1889, which was very fully discussed. Another paper, in 1893, "The Influence of his Profession upon the Social Relations of the Engineer," was part of a series on Engineers' Relations. Still another, in 1903, was again one of a series dealing with Street Railway Tracks, and was entitled, "The Relation of Street Railway Tracks to the Paving of City Streets."

He was a charter member of the Massachusetts Highway Association, organized in 1893, and its president in 1896. The Connecticut Highway Association, at Springfield, in 1897 elected him an honorary member in recognition of his "kindly influence" "upon the affairs of the association."

In 1880, he joined the American Society of Civil Engineers, and was a director of that society, 1898–1900. When this society joined with the other national engineering societies for a trip to Europe in 1889, Manley and his wife were members of the party; a trip to Europe was at that time an event.

Manley was an examiner for the Civil Service Commission of Massachusetts for inspectors from 1891 to 1913, and on civil engineer grades from the beginning in 1897 to 1913.

His work here, as elsewhere in engineering, was marked by a strong fund of "common sense," upon which in large degree his success as an engineer was based. He was, however, by no means deficient in education. In his time, engineering schools were barely in evidence. But, starting on the farm, carrying his formal education beyond the academy or high school, through the normal school, teaching several years, spending nearly a year in the army, and a year away from New England in South Africa, he was educated well beyond the limits of most of his contemporaries in engineering.

He attended the Unitarian Church at West Roxbury, was its treasurer for thirteen years, and when the Church was moved was chairman of the Building Committee for what is now used as the parish house, but was for many years occupied as the church. He was a member of the Committee on the Memorial Window, served at various times as auditor, and was a trustee of the "Bradford Fund" for thirteen years. He was also a member of the Unitarian Club meeting in Boston, and at its dinners wisely took care to sit next to strangers, rather than old friends, in order to extend his acquaintance.

Manley was an early member of the local Highland Club of West Roxbury, where he is well remembered by his friends as a devotee of the pool table. He was at one time treasurer of the club. He was also among the early members of the Boston City Club.

He was interested in his family history and became a member of the New England Historic Genealogical Society. He also had a part share which entitled him to the use of the Boston Athenæum. After his retirement he found our Society's library, the City Club, the Athenæum, and the Genealogical Rooms, convenient places for the enjoyment of his leisure hours.

He was a member of Charles W. Carroll Post No. 144, Grand Army of the Republic, located at Dedham. In the History of the Third Regiment, he contributed the chapter on Company K, of which he had been a member. He was also a Mason, the degree of Master Mason being conferred by Revere Lodge of North Bridgewater in 1863, from which he demitted in 1872, and for a time was a member of Good Samaritan Lodge of Reading.

On November 6, 1867, he was married to Susan Elizabeth Marshall, of North Bridgewater, where they started housekeeping in their native town. The following year they moved to Brighton, and shortly after bought a house in Reading. In 1875, they moved to Boston on account of Mr. Manley's employment by the City, and settled on Mt. Vernon Street, in the newly annexed suburb of West Roxbury, which was to be their home for the remainder of their lives. They had four children, — a daughter, who died in infancy, and three sons, all of whom became engineers. The oldest, Laurence B. Manley, and the youngest, Henry Manley, Jr., are members of this Society. The other son, Howard T. Manley, has been several years a resident of Mexico. Mr. and Mrs. Manley lived most happily together for nearly fifty-two years. Mrs. Manley survived him by less than two months.

Henry Manley, to his friends, was a delightful companion, pointed and quaint in his sayings and ways of doing; a typical Yankee, keen in his ways of accomplishing things. Many anecdotes might be given for illustration if this were the appropriate place. He was a good friend and neighbor, a worthy citizen, ever faithful and efficient in the many duties entrusted to him.

Among his effects were found the following verses copied by him in 1912 from "Recollections of a Lucknow Veteran 8145–1876, by Major General John Ruggles." It is thought

that he had some intention of reading them at one of the Annual Dinners, and that they may fittingly serve as a personal message to his lifelong friends in the Boston Society of Civil Engineers.

"Good-night! I am old and my blood has grown cold,
I am weary of banquet and ball;
I have shared of your best, I would go to my rest,—
Good-night to you, gentlemen all!

"From the laughter and light, I must ride through the night,
Alone from your festival hall;
Looking back through the years with no tremors or fears,—
Good-night to you, gentlemen all!

"Spur at heel, sword at side, as a man I will ride
With no dolorous trappings or pall;
No tolling of bell, but a smile for farewell,—
Good-night to you, gentlemen all!

"Fair ladies, adieu! my obeisance to you;
One kiss, lightly blown, to recall
The hey-day of life, with its love and its strife,—
Fair ladies, good-night to you all!

"The Recorder from whom no man's secrets are hid
Has called me; I go at his call.
I am ready to answer for all that I did,—
Good-night to you, gentlemen all!

"Good-night! then good-night! Though your fires burn bright,
With your lusters ablaze on the wall,
Yet the stars are agleam on the ford at the stream,—
Good-night to you, gentlemen all!"

Vol. VII OCTOBER, 1920 No. 8

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PROCEEDINGS

PAPERS IN THIS NUMBER.

"An Engineer's Impressions of Japan." Dana M. Wood.
Memoir of Deceased Member.

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Contributors are hereby notified that proof will not be submitted to them for examination unless requested before the 10th of the month preceding the month of publication.

MINUTES OF MEETINGS.

BOSTON, September 15, 1920. — A regular meeting of the Boston Society of Civil Engineers was held this evening at Chipman Hall, Tremont Temple, and was called to order at 7.50 o'clock by the President, Frank A. Barbour.

There were 110 members and visitors present, including many ladies.

The record of the May meeting was read and approved.

The Secretary reported for the Board of Government that at its meeting held on July 2, 1920, it had elected the following candidates to membership in the grades named:

Members: Messrs. Walter I. Brown, George L. Bryant, Willard G. Burleigh, Herbert S. Cleverdon, James S. Crandall, Ralph U. Cross, Walter C. Eberhard, Howard L. Foster, George P. Morrill, Thomas F. McSweeney, Martin J. O'Brien, Francis

P. Scully, Edward W. Shaw, William J. Theriault and Carl W. Wood.

Juniors: Messrs. Oliver B. Brown, William A. Clark and Harold S. Cole.

Associate: Mr. Harold L. Kinsman.

He further reported the election by the Board, this afternoon, of the following additional candidates in the grades named:

Members: Messrs. Herbert B. Allen, Karl R. Kennison and William D. Henderson.

Junior: Mr. Earle H. Cove.

Mr. Whitney moved that the vote passed at the May meeting, receiving the report of the Committee on Compensation of Engineers and sending out its recommendations to a letter ballot, be reconsidered, and it was voted unanimously to reconsider this vote. Mr. Whitney then moved, as a substitute, the following vote:

> That the report be received and the committee discharged, and that the question involved in the report be submitted to the members of the Society in the form of a questionnaire.

The motion was adopted by a unanimous vote.

The Secretary presented a memoir of Past President Henry Manley, prepared by a committee consisting of C. F. Allen, E. W. Howe and L. B. Manley.

He also presented a memoir of Robert Winthrop Pratt, prepared by a committee consisting of G. W. Fuller and Morris Knowles. Both memoirs were received and ordered printed in the JOURNAL of the Society. The President announced the deaths of two members of the Society, — John R. Burke, who died April 27, 1920, and William M. Brown, who died May 29, 1920.

By vote the President was requested to appoint committees to prepare memoirs.

He has appointed the following to membership on these committees: On memoir of John Ryan Burke, Mr. Frank W. Hodgdon, and on memoir of William M. Brown, Messrs. Howard A. Carson and Henry T. Stiff.

The speaker of the evening, Mr. Dana M. Wood, was then presented, and there followed a most interesting talk on "An

Engineer's Impressions of Japan," which was illustrated with a large number of beautifully colored slides.

Adjourned.

S. E. TINKHAM, *Secretary.*

ANNUAL FIELD DAY.

THE regular meeting of the Society for June was dispensed with this year, and in its place the members joined with the members of the New England Water Works Association in the annual field day, which was held on June 9, at Wardhurst, on Lake Suntaug, Lynnfield, Mass.

Before the dinner, athletic sports were held, and after the dinner prizes were awarded to the winner in each event. In the afternoon a baseball game was played, the Boston Society team winning the game.

The day was perfect, and each of the 109 present pronounced it the best joint field day the organizations had ever held.

S. E. TINKHAM, *Secretary.*

APPLICATIONS FOR MEMBERSHIP.

[September 15, 1920.]

THE By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

Lucas, John, Lynn, Mass. (Age 21, b. Bury, England.) Educated in public schools of Lawrence, Lynn High School and Mass. Institute of Technology; instructor in topographical engineering for Mass. Institute of Technology at East Machias. At present assistant civil engineer with Jackson & Moreland, Boston, Mass. Refers to J. B. Babcock, C. B. Breed, E. H. Cameron, J. W. Howard, A. G. Robbins and C. M. Spofford.

McCann, Frank J., Lowell, Mass. (Age 24, b. Lowell, Mass.) Graduate of Wentworth Institute in architectural construction. From June, 1916, to December, 1917, employed by construction companies in Lowell, as a draftsman, surveyor and assistant to superintendent; December, 1917, to April, 1919, in the U. S. Army; April to December, 1919, with Massachusetts Engineering Co. and Kearns Construction Co., as an architectural designer and draftsman; and December, 1919, to date with General Electric Co. as an architectural designer, draftsman and inspector of buildings. Refers to S. R. Berke, F. G. Berry, W. D. Morrill and H. C. Thomas.

Sutherland, Clarence Hale, Cambridge, Mass. (Age 36, b. Foxcroft, Me.) Graduate Harvard College, A.B., 1916; Mass. Institute of Technology, S.B., 1911; rodman, P. C. C. & St. L. Ry., summer 1909; draftsman, Manitoba Bridge and Iron Works, summer 1910; draftsman, Phœnix Bridge Co., summer 1911; draftsman and designer, Corrugated Bar Co., Buffalo, N. Y., 1912–1913; instructor, Mass. Institute of Technology, 1913–17; summer work, 1913–17, on reinforced concrete design, Corrugated Bar Co., Stone & Webster, Fred T. Ley Co.; 1st Lieut., U. S. A., 1917–19; asst. professor of structural engineering, Mass. Institute of Technology, 1919 to date. Refers to C. R. Berry, B. A. Bowman, H. B. Luther, W. F. Pike, W. D. Trask and E. L. Walker.

EMPLOYMENT BUREAU.

The Board of Government maintains an employment bureau for the Society, to be a medium for securing positions for its members and applicants for membership, and also for furnishing employees to members and others desiring men capable of filling responsible positions.

At the Society room two lists are kept on file, one of *positions available* and the other of men *available*, giving in each case detailed information in relation thereto.

Men Available.

No. 505. Age 27. High school graduate. Has had seven years' varied experience on surveying, drafting, chief of party and inspecting. Desires position as draftsman, transitman or chief of party.

No. 507. Age 34. Three years' study of architecture and design at Lawrence Scientific School; graduate of Lowell Institute School for Industrial Foremen, buildings course; five years in architect's office; three years checking in architectural squad of large engineering firm; one year architectural and structural drafting and designing. Desires position on structural, architectural, drafting or designing work.

No. 508. Age 23. Three and a half years high school; now attending Northeastern evening school. One year high school engineering and field work; one half year practical work. Desires position as chainman or rodman.

No. 509. Age 32. Fourteen years' varied engineering experience on roads, street pavements, sewers, water works, bridges and buildings. Acted as superintendent in charge of concrete bridge structure. Can do some concrete designing. Desires position with some contracting firm, where advancement is possible.

LIST OF MEMBERS.

ADDITIONS.

BADGER, A. W. 87 West St., Hyde Park, Mass.
HASKELL, G. F. 703 City Hall Annex, Boston 9, Mass.
O'BRIEN, M. J. 7 Taylor St., Medford, Mass.
SCULLY, F. P. 88 Walnut Ave., Cambridge, Mass.

CHANGES OF ADDRESS.

ALLEN, R. C. 9 Vine St., Manchester, Mass.
BARRETT, R. E. 71 Fairfield Ave., Holyoke, Mass.
FRASER, C. E. K. Oyster Bay, N. Y.
FREEMAN, E. A. Y. M. C. A., Springfield, Mass.
LARNED, E. S. 149 Highland Ave., Winchester, Mass.
LEAVITT, A. J. 119 Blake St., Mattapan, Mass.
LEWIS, G. W. 34 Banks St., Waltham, Mass.
LOUD, R. W. 67 Everett St., Arlington, Mass.
MORRILL, W. D. 48 Prospect St., Reading, Mass.
MORTENSON, E. D. 18a Rockville Park, Roxbury, Mass.
MOULTON, J. W. Care University of Porto Rico, Rio Piedras, P. R.
SHAW, A. L. 14 Beacon St., Boston 9, Mass.
SNOW, W. B. 60 High St., Boston 9, Mass.
STROUT, H. E. San Mateo, Calif.
SULLIVAN, W. F.,
Supt. and Mgr., Pennichuck Water Works, Box 425, Nashua, N. H.
TAYLOR, P. W. Riverdale Rd., Wellesley Farms, Mass.
TREADWELL, E. D. P. O. Box 246, Atascardero, Calif.
TURNER, D. L. Hotel Touraine, 9 East 39th St., New York, N. Y.
WARING, C. T. 32 Giddens Bldg., Tampa, Fla.
WARREN, H. E. 37 Temple St., Boston, Mass.

LIBRARY NOTES.

Book Review.

"Engineering for Land Drainage": By Charles Gleason Elliott, C.E., member American Society Civil Engineers. 3d edition, New York, John Wiley & Sons, Inc. Cloth, 5 x 7½ ins.; pp. 363. Illustrated.

Reviewed by C. H. Pierce.*

In this little book of 353 pages Mr. Elliott has prepared what he terms "A Manual for the Reclamation of Lands Injured by Water." This is the third edition and has been entirely rewritten since its first publication in 1902. At the time of the second edition, in 1911, Mr. Elliott stated that he sought to cover the essential features of drainage engineering as practiced in this country at that time, including descriptions of the latest developments along each line, and to make the book adapted to the use of the professional engineer and the student. In the latest edition the author has revised some parts and added to others, and has introduced some new tables which he believes correspond to results obtained in practice. Credit has been given Trautwine's Engineers' Pocket-Book, the files of the U. S. Department of Agriculture, and other sources from which diagrams or data have been obtained.

The first twenty pages consist of historical matter under the heading "Development of Land Drainage," with descriptions of methods employed in draining the English Fens and Haarlem Lake, Holland. These are of interest, but it is doubtful if the statistics and cost data for those works would be of much value in planning drainage projects in any part of this country at the present time. Various topics, such as "Drain-Tile in the United States," "Drainage in the South," and "State Drainage Laws," are passed over with brief paragraphs.

The author's discussion of "The Drainage Engineer," in Chapter II, might be read with profit by every young engineer: "He should honor his profession by exhibiting a well-balanced enthusiasm in all of its branches, and by ability and trustworthi-

* District Engineer, U. S. Geological Survey, Custom House, Boston, Mass.

ness establish himself in the confidence of all with whom he has professional or business relations." This is just as properly the code of the railroad engineer or the sanitary engineer, and it is also equally becoming all engineers "to cultivate patience, courtesy, and a sympathetic personality," as the drainage engineer is advised to do.

In the twenty-eight pages devoted to "Engineering Technique" the author has made brief mention of some of the methods used in making field surveys and in plotting the work in the office. It appears doubtful, however, if the descriptions of methods are complete enough to fully instruct a novice, whereas to an experienced engineer this description of surveying methods would be unnecessary. In describing methods of survey for contour lines, Mr. Elliott treats of two methods: "The transit and stadia method," and "the level and chain method, — the land first to be laid off in 100-ft. squares." One might wonder why the plane table method was not also suggested. In this part of the book various elementary subjects are treated at greater length than their importance warrants, as for instance, the page devoted to "Copying Maps" describes in detail the apparatus used in making blueprints. This topic is immediately followed by a well-written section on "Reports and Estimates," covering slightly less than two pages. "Drainage and How Accomplished," "The Preliminary Survey," "Underdrains and Their Location," "Selection of Drain Tile," and "Construction of Tile Drains" are chapters containing much technical information of real value to the engineer. The chapters on "Flow in Underdrains," "The Run-off from Underdrained Areas," "Size of Tile Drains," and "Flow in Open Channels" are largely theoretical and contain only one reference to the interesting and valuable facts which have been brought out through the work of the drainage engineers of the U. S. Department of Agriculture.

Chapter XIII, "The Run-off from Large Areas," contains several sections of interest. The topics: "Evaporation," "Relation of Soil to Run-off," and the table giving Flood Discharge of Streams should be of value to many engineers, although the table of Flood Discharge gives no references to floods occurring in any years except 1903, 1904 and 1905. The curves

showing relation between size of drainage area and run-off in cubic feet per second per square mile, which were prepared for drainage studies in the upper Mississippi valley and in Illinois, appear similar in form to curves for streams of New England. Several chapters in the latter part of the book deal with construction and problems incident to construction and operation of drainage systems. These chapters contain clear and concise discussions of the relative merits of different methods, with as much description as appears necessary for a full understanding of the subject. Chapters of special interest are: "Reclamation of Tidal Lands," "Drainage of Irrigated Lands," and "Drainage of Home Surroundings." In the chapter last mentioned it is shown that the drainage of farmsteads and village lots may appear insignificant when compared with extensive drainage projects, but that when considered from a sanitary standpoint the drainage of the home surroundings is of great importance, not only in the added beauty of the grounds and the better growth of shrubs and flowers, but also to the health and happiness of the resident.

Recent Additions to the Library.

U. S. Government Reports.

Central Electric Light and Power Stations. 1917.
Financial Statistics of States. 1919.
Water Supply Paper No. 436. (Missouri River Basin.)

State Reports.

Massachusetts. Report of Metropolitan Park Commission. 1919.

Massachusetts. Report of Gas and Electric Light Commission. 1919.

Massachusetts. Report of Metropolitan Water and Sewerage Board. 1919.

New York State. Preliminary Report on Sacandaga and Genesee Water Power Development. John R. Freeman. 1908.

Rhode Island. Annual Report of Public Utilities Commission. 1919.

County Reports.

King and Pierce, Wash. Report on Flood Control of White-Stuck and Puyallup Rivers. 1920.

Municipal Reports.

Holyoke, Mass. Annual Report of Board of Water Commissioners. 1919.

Melrose, Mass. Annual Report of Board of Park Commissioners. 1919.

New Bedford, Mass. Report of Sewage Disposal. 1911.

New Bedford, Mass. Annual Reports of Water Board, 1901–11.

New York, N. Y. Report of Commissioner of Bridges. 1901.

New York, N. Y. Report of Commissioner of Bridges. 1904.

New York, N. Y. Report of Bureau of Buildings. 1915.

New York, N. Y. Report of Board of Estimate and Apportionment. 1906–7.

New York, N. Y. Report upon Tunnel under East River. 1894.

New York, N. Y. Report of Board of Water Supply. 1911.

New York, N. Y. Report of Board of Water Supply. 1919.

North Adams, Mass. Annual Report of Officers, 1897, 1898, 1904–7, 1911–12.

Ogdensburg, N. Y. Annual Report of Mayor. 1897–98.

Pittsfield, Mass. Annual Report of City. 1906.

Portland, Me. Annual Report of Water District. 1908–11.

Providence, R. I. Proposed Plan for a Sewerage System. 1884.

Providence, R. I. Annual Report of City Engineer. 1919.

Quincy, Mass. Annual City Report, 1905–6.

Reading, Pa. Annual Report of Water Commissioners. 1894, 1906–7, 1907–8, 1910–11.

Reading, Pa. Annual Report of Bureau of Water. 1918.

Rochester, N. Y. Annual Report of Executive Board. 1891.

Salem, Mass. Report of Water Supply Board. 1913–15.

Salt Lake City, Utah. Annual Report of City Officers, 1905, 1906, 1916.

Somerville, Mass. Annual Report of City Engineer. 1905, 1907.

Somerville, Mass. Contract and Specifications for Wrought-Iron Reservoir. 1889.

Somerville, Mass. Contract and Specifications. Pumping Engine and Boiler. 1889.

Somerville, Mass. Annual Report of City. 1916, 1918.

Syracuse, N. Y. Report on Extent of First Works for Supplying Water to Syracuse. 1889.

Taunton, Mass. Report on Water Supply. 1875.

Taunton, Mass. Report on State Lunatic Asylum. 1878.

Taunton, Mass. Report of Water Board. 1896–1911.

Toronto, Ont. Report of Sewage and Garbage Disposal. 1889.

Toronto, Ont. Report of City Engineer. 1910.

Toledo, Ohio. Report of Water Works. 1877.

Troy, N. Y. Annual Report of Public Works. 1900, 1905, 1906, 1907.

Waltham, Mass. Annual Report of Town Officers. 1875, 1878.

Waltham, Mass. Contract and Specifications for Section 3 of Sewerage System. 1891.

Waterbury, Conn. Municipal Register. 1896–98, 1900–5.

Watertown, Mass. Report on System of Sewerage. 1891.

Watertown, Mass. Annual Report of Town Officers. 1895.

Miscellaneous.

Engineering Enquiry. Tomey Thompson. (Gift of H. S. Knowlton.)

Graphite. Department of Mines, Canada. Hugh S. Spence.

Power Development of Small Streams. Harris and Rice. (Gift of authors.)

LIBRARY COMMITTEE.

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BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PAPERS AND DISCUSSIONS

This Society is not responsible for any statement made or opinion expressed in its publications

AN ENGINEER'S IMPRESSIONS OF JAPAN.

By Dana M. Wood,* Member Boston Society of Civil Engineers.

(Presented September 15, 1920.)

Scarcely more than fifty years ago, Japan was a self-sustaining country with little or no interest in the outside world. Then came a period of years when she was getting acquainted with her neighbors, receiving visitors from all parts of the world in increasing numbers and sending her own young men and women to other countries for educational purposes. Most naturally this has led to the introduction of broadening ideas and the gradual development of business relations.

Formerly Japan was an almost strictly agricultural country. It has been an increasingly difficult problem to feed the nation. Her population is about 57 000 000, which, with a Korean population of about 17 000 000, gives the empire a total of 74 000 000 people. Japan is reputed to be one of the most densely populated countries in the world, having about 450 people per square mile.

With the opening of foreign markets an increasing amount of food and other supplies have been imported. At the same time the industries have been gradually developing, and new trades created, thus diverting some of the labor into new enterprises. Exports, principally silk, have been increasing rapidly and until recently a favorable trade balance maintained. The World

* With Stone & Webster, 147 Milk Street, Boston, Mass.

War found Japan in the position of changing from an almost strictly agricultural country to one with diversified interests in which her industrial development was rapidly becoming predominant. She realized large profits during the war, largely due to greatly inflated prices of the commodities sold in foreign markets.

To illustrate, the total production of silk nearly doubled from 1913 to 1919, while the value of all kinds of silk goods exported increased from about $122 600 000 to $409 400 000, or over three times. Total exports were about $316 000 000 and $1 050 000 000 for the same years, so that the silk industry represented about 39 per cent. of the total exports in both years.

In 1919 about 95 per cent. of all silk exported was delivered in the United States. During this same year there were sold in the United States goods of all kinds to a value of about $414-000 000, the silk products representing about 99 per cent. of the total. Japan is also noted for its porcelains, bronzes, toys and works of art.

About 35 per cent. of the total imports to Japan during 1919 was from the United States, and about 37 per cent. of these imports was raw cotton. Cotton mills are rapidly increasing in number, and considerable American-made mill machinery imported.

The foregoing has been mentioned to indicate how rapidly Japan has been changing to a country with considerable industrial development. It also indicates a frequently heard argument in favor of continued friendly relations between the two countries, — that neither country can afford commercially to lose the friendship of the other.

Pressing Engineering Problems. — Such a complete change in the life of a nation cannot be made without introducing many new engineering as well as business problems.

New shipping lines and additional boats to accommodate the increasing trade resulted, during the earlier part of this year, in a congestion at the ports. Yokohama is the most important port, and now has good docking facilities, but they became inadequate for handling the rapid increase in ocean freights. While we were in Japan some vessels were weeks in port, endeavoring

to unload. Lighters were extensively used in addition to the docks, but resulted in higher costs for handling the freight.

More serious still were the shore facilities. So much freight was being handled during the first part of this year that all warehouses were filled, and consignments were piled one upon the other in the dock yards. Customs officials could not keep up with the volume of business. As a secondary contributing factor, because of the gradual curtailment of bank credits to be mentioned later, many consignees left their goods in customs, adding to the congestion. All of this resulted in slow deliveries. One Japanese engineer stated in April that he had, to date, been unable to get machinery landed at Yokohama early in December.

What applies to Yokohama may be said also of the other principal ports, which are probably too few in number, but which must also have additional facilities if the congestion is not to continue.

The railroad situation is another contributing factor to this undesirable condition. They are narrow gage (3 ft. 6 ins.), and with their small and insufficient number of cars cannot properly handle the freight to and from the shipping points. Originally, private capital developed numerous short lines, but the Government has gradually taken over and consolidated the control until now practically all lines are operated by the Imperial Railways Bureau.

Recently it has been proposed to electrify the main lines and those where tunnels are numerous, and to broaden the gage to our standard of 4 ft. $8\frac{1}{2}$ ins. A bill was introduced in the Diet for this purpose, carrying an appropriation of $50 000 000, and it was proposed that the Government should furnish half the necessary capital, the balance to be raised from private sources. This bill has been withdrawn and the work indefinitely postponed as a result of the recent financial crisis.

Japan has already had some experience with electrified lines, the principal one running between Yokohama and Tokyo, a distance of 18 miles. Some short mountain sections, where there are numerous tunnels, are also electrified.

The trains and city trolley lines are at times badly crowded, and as a result there are three different companies contemplating

subways or elevated lines in Tokyo. Since much of this city is built on filled-in marsh lands, some interesting problems must be met, especially with regard to safeguards against earthquake shocks which are frequent.

Highways are poor for the changing traffic conditions. Originally built for foot and rickshaw travel, with very few horse- and ox-drawn vehicles, the recently increasing numbers of automobiles and auto trucks are tearing these roads to pieces. An American engineer was recently called in consultation and several experimental sections of macadam, etc., laid in Tokyo and Yokohama. It is proposed to connect the important cities with good trunk line roads, gradually extending these inland, besides improving the city streets. Except on the newer city streets built after a conflagration, no sidewalks exist, and it will prove a serious problem to widen for sidewalks and also widen the roadways, and to educate the people in their use when built. At present the people are all over the street, and auto riding is not all joy.

Bridges must be built across wide rivers and over deep gorges in the mountains. Many problems will be met in their construction.

Owing to the great increase in demand for power for industrial expansion and for the possible electrification of the railroads, and because coal is not mined in sufficient quantities or of sufficiently good quality, water-powers are rapidly coming into importance. Because of the large demand, many water-power schemes are being promoted, some obviously uneconomical, others very promising.

Building construction is active, and many new office buildings and hotels are either under construction or being contemplated. In Tokyo the height of buildings is at present limited to 90 ft. because of earthquakes; the highest actually built is 80 ft., and few exceed three or four stories. The principal types are wood frame with plaster finish and structural steel with stone finish. Many of the wealthier people are now desirous of the so-called European home. This is to be regretted, as it usually causes wide departures from typical Japanese architecture which is so attractive and adaptable in many ways. In some cases a

compromise is being made, retaining the Japanese exterior with one wing devoted to foreign-style rooms and furnishings. The introduction of furnace heat, glass windows which are modeled after our own, doors and such like features, will any one of them result in a complete departure from the present Japanese style of architecture and bring up serious problems of design, if the best features of the Japanese house are still to be retained.

Water supplies for nearly all of the largest cities have already received considerable attention, but much remains to be accomplished elsewhere. Where improvements have been made, slow sand filtration with gravity distribution is almost universally used. The rate of filtration for Tokyo is said to be an 8-ft. depth in twenty-four hours. The water runs 500 bacteria per c.c., which is reduced by filtration to about 40 per c.c. Kyoto has the only rapid filtration plant in Japan.

Much trouble is experienced in the distribution mains from breakage during earthquake shocks, which are frequent, especially along the Pacific coast. One solution now being investigated is the use of wrought-iron pipe with flexible lead joints.

Modern sewage disposal systems are not used. The bucket system is used everywhere, and the sewage is used for fertilization of the farms. The introduction of any modern system will include the problem of supplying a substitute fertilizer. Commercial fertilizers are not used to any extent.

Recent Financial Crisis. — As a result of a favorable trade balance for a considerable time, with the rapidly increasing national wealth, prices rose during 1919 and early in 1920 to unheard-of levels. The general prosperity resulted in over-optimism and a rush of development enterprises. Because industrial development had not reached a point where materials could to any large extent be obtained within the empire, large foreign commitments were made.

During the latter part of last January the Government issued orders through the Bank of Japan, the central financial institution, to curtail credits. On top of this, the trade balance for the first time in a long while became unfavorable, imports exceeding exports, and this condition has continued since. A quite recent report indicated that imports had exceeded exports for the

partial year to an amount between 500 and 600 million dollars.

The result has been, first, a gradual retrenchment, then a sudden crash in prices, some bad failures and the closing of many factories during the readjustment period. Late reports indicate a present dull state of business affairs.

Because of the financial crisis, — a near panic, — all new enterprises are temporarily halted. The fundamental conditions remain the same, however, and if Japan is to become an important nation her industries must continue to develop rapidly and many changes made from centuries-old habits.

To complicate any prediction as to how long the depression may be expected to last is the political situation both at home and abroad. At present, Japan may be said to be a militaristic nation with a paternal autocratic form of government. Much unrest and agitation for an enlarged male suffrage with larger control in government affairs exists at home; and her relations abroad toward Korea, China and Russia will have to be settled in some favorable way. Our own Japanese problem in California also offers an unfortunate chance for uneasiness in both nations.

Language. — The language is a serious difficulty encountered by the foreign engineer doing business in Japan. English is taught in all the schools at an early age, but usually by Japanese teachers, so that many can understand written but not spoken English. Along the usual tourist lines of travel English is spoken sufficiently for the foreigner to get along comfortably. Hotel clerks, railroad trainmen, usually one or more clerks in the best stores, speak English passably. Many of the bankers and business men speak it surprisingly well.

On the other hand, the Japanese study and understand only simple and pure English, and do not understand contractions, slang or common idioms. They are apt to make literal translations. Think of their mental confusion when one says, in discussing a problem, "Where do we stand now?" "Won't" and "don't" are very difficult for them to understand, and their use should be carefully avoided.

Negative questions are not used in Japanese, and their use in English is a common source of misunderstanding. For ex-

ample, you may say, "I do not believe we should plan to go to-morrow, do you?" and the invariable answer will be, "Yes." In reality, the literal translation of the corresponding answer in Japanese means, "I agree with you," or "I understand," and this is what is meant by his answer. This is a common source of business misunderstanding until the foreigner learns to avoid using the negative question.

The language is difficult because it is guttural and therefore very hard to pronounce correctly. Yet it is quite essential, if one intends going without an interpreter or to inland points where English is rarely or never heard, to acquire at least enough of it to be able to order meals and accommodations, and to talk on business matters to a limited extent. Otherwise, even with an interpreter, one's progress is very slow in acquiring the information desired. It is quite different from traveling in European countries, where language similarities can be found and the meaning often guessed correctly. The written Japanese is impossible to acquire in a short time, and the spoken has no similarity to English in sound or construction. "O Hayo!", for example, means "Good-morning!" but translated literally is, "Honorable early."

Geography of Japan. — The Japanese Empire includes a main island known as Hondo; Shikoku and Kyushu closely adjacent to the south; Yezo, one half of Saghaliero near Siberia and known as Harafuto, and the Kuriles to the north; still further south the Luchu Islands and Formosa; and Korea. The northern half of Saghalien and the Russian port of Nikolaevsk have recently been occupied by the Japanese military forces, and may, like Port Arthur, Vladivostock and the Shantung peninsula in China, be under their authority for some time to come. Altogether, exclusive of the temporarily occupied territory, the empire includes $5\frac{1}{2}$ large islands and about 4 000 small ones, besides Korea, which stretch in a long, thin line for nearly 2 000 miles, from 22 degrees to 51 degrees north latitude and 120 degrees to 156 degrees east longitude. Hondo has a maximum width of 200 miles, with an average of 110, and is about 800 miles long, and has an area of about 86 300 square miles.

The entire empire is subject to earthquakes, but some sections more than others, both as regards severity and frequency of occurrence. The effect upon design should be considered for every major structure built.

Dr. F. Omori, of the Tokyo Imperial University, and an international seismological expert, states that the islands were originally formed by pressure from the direction of Asia. The Japan Sea is relatively shallow with a maximum depth of 3 000 meters. On the Pacific Ocean side there is a sudden deepening to 8 000 meters. It is along this side, south toward Formosa and north to the Aleutian Islands, where the zones of greatest seismological disturbances exist, while the Japan Sea side is subject to only occasional and slighter shocks.

Rivers in Hondo, about one third of which was included in our investigations, are of the mountainous type, quick falling except toward the mouths, and subjected to sudden heavy floods carrying much silt and rolling large bowlders. The river channels shift after every big flood. For these reasons it is necessary to design river structures for conditions met with only in our own most mountainous sections. Rivers seldom exceed a length of 110 miles, and drainage areas of 2 000 square miles.

The climate varies from the torrid to the frigid, and remarkable changes are found in a few hours' travel from the coast into the mountains, or from the south to the north.

Observations of precipitation and other meteorological data are available since 1892 at numerous stations, about 2 000 stations being maintained at the present time. Rainfall records are kept in millimeters, but are otherwise obtained and reported in a manner quite similar to that used by the United States Weather Bureau.

The standard rain gage consists of a cylindrical receiver 20 cm. in diameter, with non-evaporating receiving apparatus and glass collecting bottle. The gage is usually sunk into the ground to such a depth that the top will be 20 cm. above the ground. Often two are installed, one being read at 10 A.M. and the other every hour, or six times daily.

Records indicate a variation of from 35 to 138 ins. in different parts of the empire. Tokyo averages about 60 ins., with a range

of from 45 to 76 ins. Intense storms at Tokyo show a twenty-four-hour total of from 7 to 8 ins.

The run-off records are not very reliable, as they have been obtained for only about two years. During the war such work was stopped, but was resumed about a year and a half ago, these latter records not yet being available. Methods similar to those employed in this country are used, but the men have not yet become skilled either in practice or theory.

Indications are that the average run-off is from 3 to 5 or even more second-feet per square mile. Minimums are high, from 1.25 to 2.50 sec. ft. per square mile. Run-off varies during the year in about the same ratios as in America, high water occurring in the summer months. The range in stage from low to high water is from 18 to 40 ft., with one extreme case noted of 70 ft. This introduces special problems in tailrace design at power plants.

Tokyo, the largest city, has a population of 2 300 000 (some reports give as high as 3 000 000), Osaka has about 1 400 000, while Kyoto, Yokohama, Kobe and Nagoya vary from about 800 000 to 500 000. These are the largest cities in the empire.

Water-Power Development. — Japan has already installed many hydroelectric developments, ranging from 100 to 1 100 ft. head and 5 000 to 50 000 k.w. capacity, at what may be considered the more important installations.

Because of the quick control required at dams, the roller-crest type has been installed in a number of instances and is quite popular with Japanese engineers. Special sand catching designs were seen in use. Overhead gate mechanisms or head gates are universal, and separate generator fly-wheels were frequently observed. These represent the most obvious departures from our practice.

Essentially all power developments are of the low diverting dam type, with long waterways, usually with long tunnels and shorter canal sections, open hillside forebay, and pipe lines to the power house. Storage and pondage are rarely available or used, and only a few plants can be said to be developed with this in view. Natural storage sites and lakes are rarely to be found.

At those possible sites that do exist, the intensive cultivation of the ground offers a serious handicap.

Conclusion. — Because of the broad scope of this article, it has been possible merely to outline some of the many interesting impressions received and observations made while in Japan.

The political and economical situation in the Far East is fully as interesting as the engineering. Along these lines, Mr. Thomas W. Lamont said, in the Boston *Transcript* of September 15, 1920:

"Japan is commercially handicapped by the policy of the so-called military party, whose philosophy of force clashes with the liberal ideas of Japan's manufacturers, great merchants and bankers.

"The business men believe their nation's development should be along lines of peaceful trade and the cultivation of good-will, while the military party, 'which of recent years has been so strong as almost to constitute an actual super-government, still thinks the world is ruled by force rather than by ideas. At the present time this policy, which has resulted in tremendous taxation to maintain the army and navy, will prevent American coöperation on a large scale in developing Japan's industries.' "

MEMOIR OF DECEASED MEMBER.

ROBERT WINTHROP PRATT.*

Robert Winthrop Pratt, consulting, civil and sanitary engineer of Cleveland, Ohio, was born at Brookline, Mass., on December 21, 1876. He was the son of Grace Otis (Kellogg) and Robert Winthrop Pratt, and traced his ancestry to John Alden.

He was graduated from the Boston Latin School in 1894, with high rank, and entered the Massachusetts Institute of Technology the same year, where he completed a civil engineering course in 1898, receiving the degree of bachelor of science.

Mr. Pratt then served as engineering assistant to the Massachusetts State Board of Health, where he had previously been employed during school vacations. Later he was employed as instrumentman on grade-crossing work, in the Engineering Department of the Boston and Albany Railroad. In June, 1899, he returned to the Massachusetts State Board of Health, as assistant engineer, and was engaged in making investigations and preparing reports on existing water supply and sewage works in the state, and also preparing reports on plans for proposed work.

In June, 1903, Mr. Pratt became chief engineer of the Ohio State Board of Health, in which position he was required to investigate and pass upon several hundred plans for proposed water supply and water purification, sewerage, sewage treatment, refuse and garbage works. His recommendations were used as a basis of action by the board of health in acting upon plans. He was also placed in charge of a special investigation, by authority of the legislature, of all existing water-purification and sewage-treatment plants in the state. During this time he served a number of cities in Pennsylvania and also the city of Wyandotte, Mich., on problems connected with water supply and sewerage. He also acted as special hydrographer of the United States Geological Survey and was in charge of the gaging work then being conducted by that department in Ohio.

From July, 1910, to July, 1911, when on leave of absence

* Memoir prepared by George W. Fuller and Morris Knowles.

from the Ohio State Board of Health, he held the position of director of sanitary engineering for the republic of Cuba. He was engaged in making investigations and recommendations for the improvement of sanitary conditions, as well as for plans of water supply and water purification for a number of Cuban cities.

Mr. Pratt was joint author with Prof. L. P. Kinnicutt, of Worcester Polytechnic Institute, and Prof. Charles E. A. Winslow, then of the Massachusetts Institute of Technology, in the comprehensive and favorably received text and reference book entitled "Sewage Disposal."

From 1911 to the time of his death he maintained an office in Cleveland in the practice of civil engineering, largely upon municipal work. A large portion of the time was spent on work for the city of Cleveland, in the design of the filtration works, and in making investigations for the treatment of the city sewage. During the last ten years he was retained by many city, county, or state governments in consulting, designing and supervising work. His work covered principally Ohio, Pennsylvania, Michigan and Ontario.

During the World War he was employed by the United States War Department as supervising engineer on the construction of Camp Sherman, Chillicothe, Ohio (capacity 40 000 men), one of the original sixteen cantonments, planning and directing the construction of water supply, drainage, sewerage, sewage treatment and roads. He was also engaged by the United States Shipping Board to supervise utilities necessary for industrial housing developments in Wyandotte, Mich., and Lorain, Ohio, and similarly served the United States Department of Labor, on its housing project at Alliance, Ohio.

The most important work in Michigan was an investigation of the Detroit water supply, with reference to filtration and other improvements, including the supervision of the operation of a demonstration filtration plant. At the time of his death he was connected with several projects of various kinds.

Mr. Pratt was a member of a number of professional societies, as follows: American Society of Civil Engineers, New England Water Works Association, Boston Society of Civil Engineers,

Engineers Society of Pennsylvania, Cleveland Engineering Society.

Probably no better tribute can be written than that prepared by his classmate and life-long friend and associate, Prof. C.-E. A. Winslow, of Yale University, who in writing for the *Technology Review* says in part:

"To those who knew the man and knew his work, these summary statements of positions filled and work accomplished are significant of a unique and fruitful public service. The science of municipal engineering at many points bears the impress of Winthrop Pratt's constructive vision, for he never feared to do the new things which his clear and alert mind felt to be sound and practical. The immediate and tangible results of his labors are seen in hundreds of municipalities in this country and in Cuba, and thousands of men and women have been safeguarded from water-borne diseases by the sanitary works which he made possible.

". . . Behind the work and in the work is the man; and it is of the man, Winthrop Pratt, that his classmates are thinking with a sense of keen and vital loss. His big frame and his slow, kindly smile were the outer signs of a nature that was at once strong and gentle. He was a tireless and enthusiastic worker, a clear and sound thinker, a born business man with a Yankee love of bargaining. Yet he was always patient and fair-minded and considerate of others. His contracts were secured because his integrity inspired confidence. His subordinates were devoted because his character won their complete loyalty. Winthrop Pratt's life was a successful life. His friends, while they mourn a deep and personal loss, can feel proud of a career which, even though cut short in its prime, is builded imperishably into the progress of engineering and the development of our country, and of a life which leaves behind it the memory of a strong and upright and lovable man."

Mr. Pratt had a pleasing personality which gained friends for him wherever he went. He had a broad outlook, and radiated confidence and good-will. On June 1, 1903, he was married to Elizabeth Southwick, of New York City, who survives him, with two sons and two daughters. After a short illness of pneumonia, he passed away at his home in Cleveland on the morning of February 2, 1920. The engineering profession loses an earnest student and his associates a cordial and sincere friend.

Vol. VII NOVEMBER, 1920 No. 9

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PROCEEDINGS

PAPERS IN THIS NUMBER.

"Dorr Systems of Sewage and Trade Waste Treatment." R. H. Eagles.

Memoir of Deceased Member.

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Contributors are hereby notified that proof will not be submitted to them for examination unless requested before the 10th of the month preceding the month of publication.

MINUTES OF MEETING.

BOSTON, October 20, 1920. — A regular meeting of the Boston Society of Civil Engineers was held this evening at Chipman Hall, Tremont Temple, and was called to order at 8 o'clock by the President, Frank A. Barbour.

There were 160 members and guests present.

The record of the last meeting was read and approved.

The Secretary reported for the Board of Government that it had elected to membership at its meeting this afternoon the following candidates in the grades named:

As a member — Mr. Erwin Harsch; and as juniors — Messrs. Harold P. Etter and George Bason Morgan.

The Secretary submitted for the committee appointed for the purpose, Messrs. Henry F. Bryant and Edward W. Howe, a memoir of John C. Olmsted, a member of the Society.

By vote the memoir was accepted and ordered printed in the JOURNAL of the Society.

After making announcements of forthcoming meetings of the Sanitary Section and of the American Association of Engineers, the President stated that the program for the evening would be a series of experience talks on Wood and Concrete Piling, and called on Past President Charles R. Gow for the first contribution. Colonel Gow responded with a most interesting and instructive talk on the art of driving piles, drawn from his large and varied experience. He was followed by Past Presidents J. W. Rollins, F. W. Hodgdon and H. F. Bryant, and by Messrs. John T. Scully and H. F. Sawtell of the Society. Mr. J. W. Taussig, of the Raymond Concrete Pile Company, and Mr. F. A. Waldron, of New York, also contributed their experiences in pile foundation work.

At 10.30 Vice-President Weston, who was in the chair, declared the meeting adjourned.

S. E. TINKHAM, *Secretary*.

APPLICATIONS FOR MEMBERSHIP.

[November 15, 1920.]

THE By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Goverment will not consider applications until the expiration of twenty (20) days from the date given.

ARCHIBALD, HENRY CAMERON, Everett, Mass. (Age 29, b. Everett, Mass.) Graduate Tufts College in 1915 with degree of B.S. in civil engineering. Entered employ of Boston & Maine Railroad, in the structural engineering department in June, 1915, and has remained continuously with that company ever since, with exception of twenty-seven months in the U. S. Army, fifteen of which were spent in France with 71st Artillery, and was regimental and battalion orientation officer in charge of the topographical work of reconnaissance. Since returning to the B. & M. R. R. has been squad leader in charge of general stress analysis of bridges and at present in charge of masonry and concrete work of the office. Refers to B. W. Guppy, Pusey Jones, A. W. Knowlton and J. B. Mailey.

BROWN, WILLIAM A., East Boston, Mass. (Age 28, b. East Boston.) Graduate of Mechanic Arts High School, 1910; of Lowell Institute for Industrial Foremen, 1916; and of the U. S. Navy Steam Engineering School in 1918. Draftsman with N. E. Tel. and Tel. Co., 1910–1911; with Edison Electric Illuminating Co., 1911–1913; with building department, General Electric Co., 1913; draftsman and designer in construction department, Swift & Co., 1914; on topographical survey for Stone & Webster, 1915, from Dec., 1915, to Oct., 1917, with H. S. Kimball and White, Weld & Co., as draftsman, designer on industrial and power plants; Oct., 1917, to May, 1919, Ensign U.S.N.R.F., engineering duties; June to Sept., 1919, U.S.S.B., division of operation and repairs; Sept., 1919, to April, 1920, mechanical designer with H. M. Hope Engineering Co., New Haven, Conn.; and since April, 1920, structural draftsman and designer with C. T. Main. Refers to H. S. Kimball, C. R. Main, J. F. Osborn, M. E. Pitman and F. J. Wood.

COWLES, MARTIN WARREN, Springfield, Ill. (Age 26, b. New Haven, Conn.) Graduate Mass. Institute of Technology, 1915, with degree of S.B. in sanitary engineering. Until April, 1916, was employee of Prof. G. C. Whipple and as assistant at M. I. T. summer camp at M. I. T. water analysis laboratory. From April, 1916, to Sept., 1918, assist. sanitary engineer, Illinois State Health Dept.; Sept., 1918, to March, 1919, 2d Lieut., Sanitary Corps, U. S. A., stationed at Camp Greenleaf, Ga., and Sheridan, Ala., San. Squad 86, also on as assist. camp engineer; March, 1919, to May, 1920, analyst and assist. engineer, Illinois State Health Dept., in charge of water analysis laboratory; and from May, 1920, to date, senior assist. engineer including responsible charge of laboratory, half time field work and half laboratory supervision. Refers to J. W. Howard, Dwight Porter, G. W. Simons, G. C. Whipple and Edward Wright.

CRONIN, WALTER L., Boston, Mass. (Age 38, b. Boston, Mass.) Graduate of Mechanic Arts High School and Mass. Institute of Technology, 1904. Taught one year in University of Illinois; fourteen years' experience in construction and design of buildings; employed by the Commonwealth

of Massachusetts as supervisor of construction for two years, and by City of Boston as building inspector, superintendent of construction and construction engineer for nearly seven years; was member of committee which revised building laws of Boston. At present with J. M. & C. J. Buckley Co., Boston. Refers to J. R. Nichols, E. F. Rockwood, H. E. Sawtell and J. R. Worcester.

KENT, SILAS STANLEY, Lowell, Mass. (Age 33, b. Meriden, Conn.) Graduate of Harvard College, 1910, and from Harvard School of Applied Science, 1911. Summer 1910, assistant in surveying at Harvard engineering camp; 1911–1913, engineering clerk and later assistant engineer in Hydraulic Division of Stone & Webster Eng. Corp.; 1914, with J. A. Loyster, Cazenovia, N. Y., on machine design and assembly; 1915–1917, special assistant with Mass. Commission on Waterways and Public Lands, in charge of water conservation investigation; 1917–1919, on active duty in U. S. Naval Reserve, served as commanding officer of U.S.S.C. 260, and as engineer officer and navigating officer of U.S.S. *Piqua*, 1919–20, and at present, assistant engineer with Proprietors of the Locks and Canals, Lowell, Mass. Refers to X. H. Goodnough, C. H. Pierce, A. T. Safford, G. F. Swain, W. F. Williams and D. M. Wood.

RICHARDS, WALTER CARLETON, Weymouth, Mass. (Age 21, b. Weymouth, Mass.) Educated in Weymouth Public Schools and Engineering School of Northeastern College. Rodman and transitman with Whitman & Howard for sixty-four weeks; from Sept., 1919, to June, 1920, assistant with Coöperative School of Engineering, Northeastern College; July and August, 1920, with engineering department of Manhassett Manufacturing Co., Putnam, Conn.; Aug. and Sept., 1920, with George W. Perry, city engineer, Putnam, Conn.; and Sept. and Oct., 1920, with Massachusetts Dept. of Public Works, Highway Division, as rodman. At present member of Class 1921, Coöperative School of Engineering, Boston. Refers to R. H. Barnes, E. W. Branch, C. S. Ell, Channing Howard, P. C. Nash and H. C. Thomas.

EMPLOYMENT BUREAU.

THE Board of Government maintains an employment bureau for the Society, to be medium for securing positions for its members and applicants for membership, and also for furnishing employees to members and other desiring men capable of filling responsible positions.

At the Society room two lists are kept on file, one of positions available and the other of men available, giving in each case detailed information in relation thereto.

Men Available.

No. 510. Age 28. Graduate of Tufts College, 1914, B.S. in structural engineering. Six and a half years' experience on designing and detailing on structural steel and concrete, drafting and designing on submarines in U. S. Navy, and as structural steel draftsman, making and checking shop details. Desires position as structural designer or draftsman on either steel or concrete.

No. 511. Age 23. Graduate of Mechanic Arts High School and studied at Northeastern College of Civil Engineering. Seven months as transitman; one year assistant engineer and draftsman on railroad location and construction, bridge construction; one year as assistant engineer and draftsman on general surveying in and about Boston. Desires position as assistant engineer, transitman or draftsman.

No. 512. Age 29. Graduate of high school and of Northeastern College, two years University Extension courses. Three years' experience as draftsman and transitman; five years as chief of party and draftsman on construction and layout of tracks; one year as designer on mills and buildings; late experience on design of railroad structures, buildings, municipal work and as resident engineer in the field. Desires position requiring the above experience.

No. 513. Age 28. Graduate of Syracuse University, 1915, degree of C.E. Six months supervisor on concrete road construction; two and a half years as timekeeper, paymaster and cost accounting; six months equipment clerk with contractor; one and a half years as estimator and office supervision of construction; six months purchasing and expediting material; eight months on concrete drafting and designing; two months as piling inspector. Desires position with field engineers on construction, especially heavy.

LIST OF MEMBERS.

ADDITIONS.

Henderson, William D. 21 Woodward St., Boston, Mass.
Kennison, Karl R. 18 Tremont St., Boston 9, Mass.

CHANGES OF ADDRESS.

Babbitt, John H. 1847 East 86th St., Cleveland, Ohio.
Bacon, W. Herbert 405 City Hall Annex, Boston 9, Mass.
Barry, C. Gardner 10 Blackwood St., Suite 8, Boston, Mass.
Beugler, Edwin J. Care Foundation Co., 120 Liberty St., New York, N. Y.
Eglee, Charles H. 715 Tremont Temple, Boston 9, Mass.
Hathaway, Erwin O. 410 Hamm Bldg., St. Paul, Minn.
Hering, Rudolph. 140 West 69th St., New York, N. Y.
Horton, F. H. 452 Tyler St., Gary, Ind.

MAWNEY, R. W. 17 Park St., Room 4, Attleboro, Mass.
MOORE, RUFUS R. 93 Binney St., Boston 17, Mass.
MORSE, W. F. 916 Hippodrome Bldg., Cleveland, Ohio.
SHAW, A. L. 14 Beacon St., Boston 9, Mass.

RECENT ADDITIONS TO THE LIBRARY.

U. S. Government Reports.

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Effect of Curing Conditions on Wear and Strength of Concrete. Duff A. Abrams.

Effect of Vibration, Jigging and Pressure on Fresh Concrete. Duff A. Abrams.

Design of Concrete Mixtures. Duff A. Abrams.

Modulus of Elasticity of Concrete. Stanton Walker.

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Beiträge zur Geschichte der Technik und Industrie. Conrad Matscho.

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Vol. VII NOVEMBER, 1920 No. 9

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PAPERS AND DISCUSSIONS

This Society is not responsible for any statement made or opinion expressed in its publications

DORR SYSTEMS OF SEWAGE AND TRADE WASTE TREATMENT.

By R. H. Eagles.*

(Presented before the Sanitary Section, October 6, 1920.)

This paper will endeavor to point out the advantages made possible by the application of continuous sedimentation and mechanical sludge removal in connection with sewage treatment. It will describe chiefly the results which have been obtained by the use of the Dorr Continuous Thickener, which has been adapted to this field under the more pertinent name of the Dorr Sewage Clarifier, and it will suggest future possibilities. It is the hope of the writer that your Society will be interested in reviewing the history and theory of Dorr equipment and processes, in view of their recent introduction into the field of your activities.

Sedimentation is, broadly speaking, the foundation of all systems of sewage and trade waste treatment, and it also plays an important part in water purification methods. It is an essential factor in wet metallurgical operations and many chemical processes. Playing such an important part in the world's industry, it is not surprising that it should have been studied as an individual science, to determine the governing factors and to lead to some standardization.

The theory of sedimentation, on which the design and ca-

* With the Dorr Company, 101 Park Avenue, New York, N. Y.

pacity of Dorr Sewage Clarifiers is based, is somewhat different from that generally accepted, and is worthy of discussion here.

Generally speaking, the basic factor in causing solid particles to settle from a flowing liquid is a decrease in current velocity to secure the maximum attractive effect of gravity upon the particles. This effect would normally be expected to result from the expansion of the cross-sectional area of the flow into any shape of basin.

The assumption is doubtless the basis of the general practice of figuring sedimentation basin capacity to give arbitrary volume detention in hours. In our opinion, this basis is not entirely correct, as it assumes that the time required to fill a basin under a certain flow will be the period of detention, whereas, in actual practice, this would mean perfect distribution of flow across the entire cross-sectional area of the basin. This condition is next to impossible and difficult to even approach.

The use of " over and under " baffles in single-story settling basins has been frequently used to approach this ideal distribution of feed, but it would appear that the constriction in cross-sectional area of flow at each baffle is defeating the original purpose of the basin by increasing current velocity at those points.

We have, therefore, relied on the more positive method of expanding the *surface area of flow* to a maximum, securing uniform surface distribution by radial flow from the center of a cylindrical tank to uniform flow over a peripheral weir. This reduces the question of settling basin capacities to a matter of allowing sufficient surface (or settling area) to narrow the depth of the surface zone of flow to a minimum, so that particles will have a minimum distance to settle below the influence of the flow zone into the quiescent zone.

The basis for computation of settling areas of Dorr Sewage Clarifiers is the rate of subsidence of the solids to produce an effluent of a certain clarity.

In dilute suspensions, such as sewage or trade wastes, the volume represented by the settled sludge and its contained water is so small in comparison with the total flow of influent that for purposes of estimation it may be neglected, and the

assumption that the amount of inflow is equal to the amount of effluent is on the side of safety.

On this assumption a rate of subsidence of one vertical foot per hour would represent a settling capacity of $7\frac{1}{2}$ gals. per sq. ft. of surface per hour, since there are $7\frac{1}{2}$ gals. in a cubic foot. In like manner a rate of subsidence of 2 ft. per hour would represent a capacity of 15 gals. per sq. ft. per hour, and so on. The settling area required for a flow of 100 000 gals. per hour and rate of subsidence at 2 ft. per hour would be $100\,000/15 = 6\,667$ sq. ft., or a tank 94 ft. in diameter.

While the figure thus obtained is the general basis of computation, experience has shown that there are a number of factors which must be considered before final estimation, and that additional area must be allowed for according to conditions met with in each particular problem. These allowances are necessary on account of the following: (*a*) velocity of surface flow, (*b*) velocity over weir, (*c*) variations in quantity of flow, (*d*) variations in chemical and physical character of flow, (*e*) variations in temperature.

It is seen that the clarification capacity of any sedimentation tank or basin is directly dependent upon the surface area and independent of the depth except in special cases of flocculation, to be discussed later.

In other words, two tanks being fed under identical conditions, each producing an effluent of the same degree of clarity, will show a capacity in gallons per hour in direct ratio to their respective areas, i.e., one having twice the area will have twice the capacity.

It has been stated that under normal operating conditions the flow of material across the basin from feed to overflow weir takes place in a surface layer of relatively shallow depth, dependent upon varying conditions, and that the true period of detention is measured by this volume displacement which is largely independent of the depth of the basin.

It is true, however, that where periodic removal of the sludge takes place a certain depth must be allowed for sludge storage, but where continuous removal occurs, as in a Dorr clarifier, one foot in depth is theoretically as good as six feet,

as far as the clarity of the effluent is concerned. In actual practice this fact is demonstrated in many successful installations of Dorr tray thickeners, handling somewhat heavier solids. With a settling tank of given volume, the original settling capacity in gallons per hour is approximately doubled by inserting a single-tray mechanism (doubling the settling area), tripled by inserting two, and so on.

Thickening of the settled sludge is an independent process, governed by entirely different principles than those of clarification. In thickening, the period of detention is the governing factor, which implies a certain volume capacity in the tank or basin for thickening; and where thickening is required depth comes in for consideration.

However, there are cases in sedimentation where the problem of thickening is not of prime importance, as, for example, the sedimentation of raw sewage. Here the chief requirement is a removal of all the solids which will settle within the limits of economical tank areas leaving an effluent containing only the finest organic solids and colloidal matter.

Under these conditions the continuous removal of settling solids in a very shallow tank, with practically a flat bottom, will suffice. Moreover, owing to the putrescible nature of the material handled, the continuous removal of such material with minimum period of detention is a most desirable condition.

While the basic factor in design of clarification units is area, there are a number of other factors which have a most important bearing on clarification efficiency.

The design of the Dorr sewage clarifier fulfills the following conditions:

1. Even distribution of flow from feed to overflow weir.
2. Maximum length of overflow weir consistent with practical design.
3. True level and alignment of overflow weir.
4. Absence of obstruction (such as baffles) which will create eddies and stray currents.
5. Protection in certain cases against formation of wind riffles.
6. Elimination of gas generation.

7. Continuous removal of settling solids in such a manner as not to create any interfering currents.

The question of overflow velocity at weir is an extremely important one. Upward currents are created which tend to lift the lighter solids and carry them over. Light solids, which have settled to a depth of 12 ins. by the time the outer limits of a tank are reached, are sometimes caught in the zone of this upward current and removed in the effluent, thereby defeating the process of sedimentation for such particles.

The depth at which these effects are noticeable is directly dependent upon the weir velocity, and by securing the maximum length of weir consistent with uniform distribution, the condition will be best cared for.

Flocculation.

The requirements as to degree of clarification will generally vary with every problem. In cases where the very finest solids and colloidal matter must be removed, flocculation must be resorted to. This agglomeration of fine particles into readily settleable floccules is brought about by the introduction of certain electrolytes or coagulants, and the method is commonly known as "dosing."

In many cases the floccule formation is rapid and complete, but in others a slow rate is observed. As the floccules grow, the rate of settling increases, and the maximum rate of settling may not occur until after a period of thirty minutes or more. Under these conditions a certain period of detention is essential in order to take advantage of the maximum settling rate. This condition is obtained in a clarifier by submerging the feed well the proper distance for volume detention, with due regard to proper distribution and elimination of short circuits.

The prime function of the slowly rotating mechanism, which is the essential feature of the clarifier, is to mechanically collect all the solids which settle in a condition suitable for removal by pumping or gravity.

The design of a typical sewage clarifier is shown in Fig. 1, and an actual installation in Fig. 2. The four radial arms with

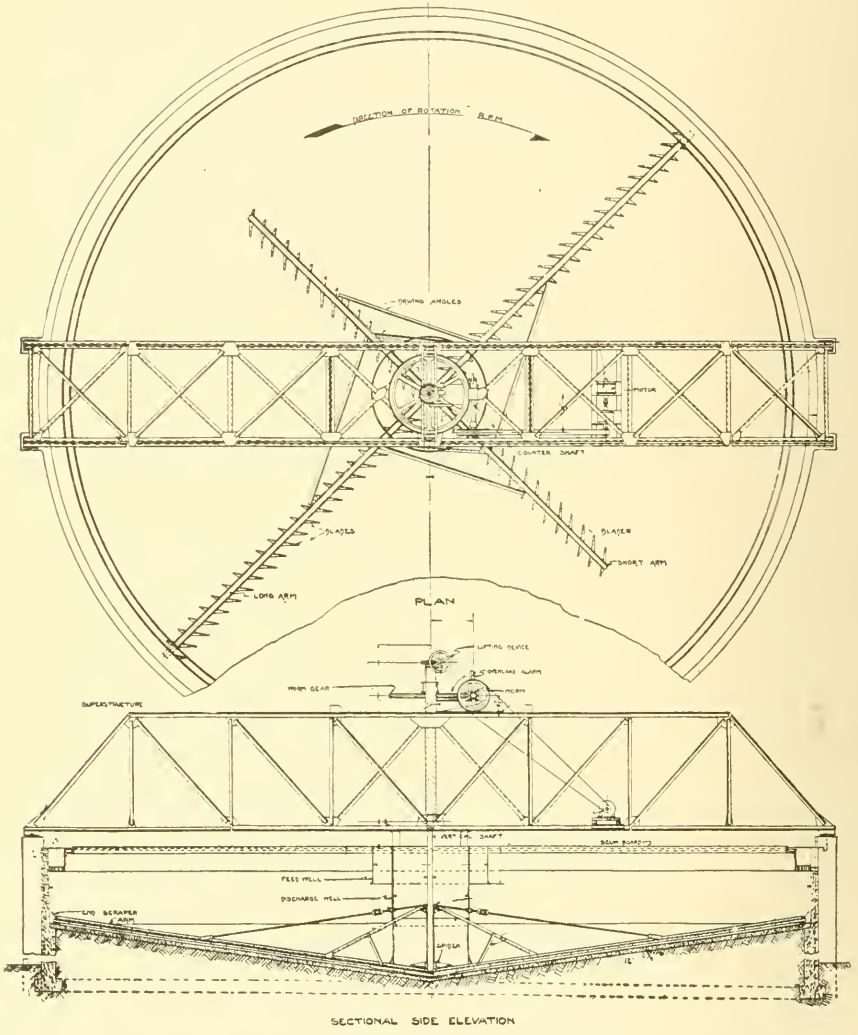


FIG. 1. — THE DORR SEWAGE CLARIFIER.

plows attached slowly sweep the entire bottom of the basin, moving all solids to the center. Arriving at the center, they rise into the central sludge well, due to the piling-up action of

the plows. As sludge is pumped from this well, additional sludge will flow in by gravity under the lower edge of the well.

The collected solids are piled up by the plows all around the outside of the well and form a sludge seal around its bottom

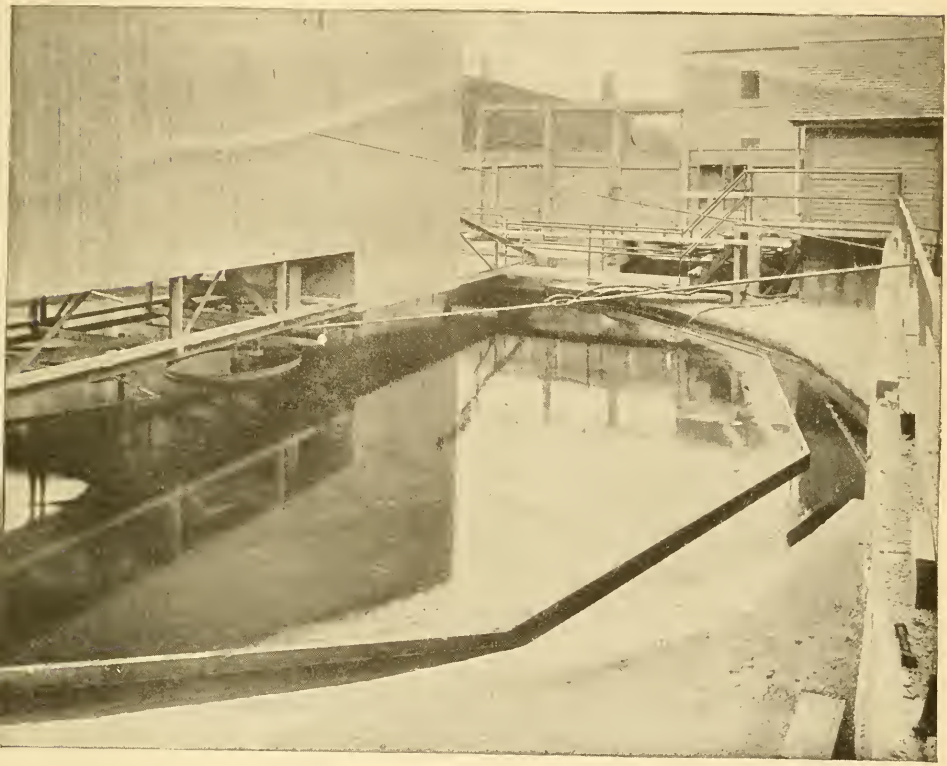


FIG. 2. — THE DORR SEWAGE CLARIFIER AS INSTALLED AT THE NATIONAL CALFSKIN COMPANY.

opening, so that only the thickened sludge can find its way into the well when the sludge pump is operating.

A thickening action takes place by reason of the compacting effect of the plows, which tend to press the sludge particles together in moving them to the center. At the same time the plows open up channels in the sludge bed, to allow the water which is squeezed out to escape.

The result is a sludge — delivered to the point of discharge in a considerably thicker condition than could be obtained by the compressing effect of gravity in a shallow basin.

At one plant a 32-ft. diameter clarifier is handling an average of 600 000 gals. daily, with a 95 per cent. removal of settleable solids and producing a sludge that has analyzed as low as $67\frac{1}{2}$ per cent. moisture, and recently averaged 70 per cent. The sewage treated is domestic, combined with gas-house and straw-board-factory wastes. A cone-bottom type settling basin, with 97 degree bottom slope (Dortumud type), produced a sludge of $93\frac{1}{2}$ per cent. average moisture content, operating under identical conditions. The clarifier was only one half as deep as the other tank.

The efficiency of the shallow clarifier on straight sedimentation of sewage as demonstrated by this installation indicates a favorable application to the so-called sedimentation-separate sludge digestion system of sewage treatment. It represents a considerable reduction in cost over the two-story tank system, by reducing expensive construction, with the resulting deep excavation of pumping.

At the Milwaukee testing station the sewage clarifier gave good service in de-watering activated sludge. In this case, it is essential to insure rapid and continuous sedimentation on account of the septic tendency of the aërobic sludge cultures. Difficulty has been experienced at other activated sludge plants using the slower fill and draw system. The Sanitary District of Chicago is installing seven 24-ft. sewage clarifiers at the Desplaines River experimental plant, for continuous sedimentation, as at Milwaukee.

Dorr Systems of Trade Waste Treatment.

In general, problems of this nature possess a peculiar aspect in that they entail a continual added operating expense without realization of material gain. Manufacturers are accustomed to securing a definite return on every dollar they spend, representing investment.

In most cases no definite advantage accrues from treating the waste waters, either from increased plant efficiency or from

improved working conditions. The nuisance usually arises a mile or more downstream, and in many cases the offended residents are entirely unaware of the exact source of the nuisance, and consequently abatement brings no gratitude to the man who spends the money. But the ever-watchful eye of the state health authorities is guarding the public health and happiness, and it is to avoid complications from this source that treatment plants are usually installed.

Representing an added expense, an essential feature is to equip the sewage treatment plant with all possible labor-saving devices, and to insure uniform results without technical supervision. It is on this basis that the sewage clarifier has been adapted to plants of this nature, — that is, to substitute continuous sedimentation methods with mechanical sludge handling for intermittent and manual cleaning methods with the resultant higher operating cost. A number of successful installations have proven the value of the clarifier in this field.

Among the vaious types of industrial waste waters which we have studied and designed plants for are the following: Tannery waste waters, glue and gelatine waste waters, packing-house waste waters, textile mill waste waters, milk products waste waters, dyestuff waste waters, acid mine waters, metal mill pickling liquors.

A brief discussion of the general features of these wastes may be of interest.

Tannery Waste Waters.—The treatment of tannery waste waters resolves itself largely into the problem of securing a maximum beneficial effect by interaction of the various types of liquors discharged. By proper regulation of the discharge of the ionizing or precipitating tanning liquors, a considerable proportion of the offensive dissolved animal matter in the beam-house wastes will be thrown out in solid form, removable by sedimentation.

The chief reasons for the failure of the numerous home-made settling basins are: lack of sufficient capacity, lack of intelligent operation, and failure to keep them clean on account of labor costs and disposal of the large sludge volumes. An efficiently operated sedimentation unit of proper design, together

with intelligent manipulation of the various wastes previous to their discharge, will produce a clarified effluent containing no appreciable amount of settleable solids, and but a small amount of suspended solids. Further purification, including removal of all color and odor, can usually be effected by sand filtration or lime dosing, according to the conditions.

Glue and Gelatine Waste Waters.—Problems of this nature have been generally handled as straight sedimentation problems for the removal of all solids which will settle. The Dorrco screen has been used in most cases preceding the clarifier. The screenings recovered are put back into the manufacturing process.

To secure an entirely clear effluent from these wastes it is necessary to break up the colloidal nature of the waters caused by the high concentration of spent milk of lime in the form of calcium bicarbonate. This effect can be obtained by the introduction of carbon dioxide to convert the bicarbonates to normal carbonates which will settle. One plant was designed on this principle, utilizing waste flue gas as a source of carbon dioxide, but it has not yet been completed.

Packing-House Wastes.—An important feature to be considered in the treatment of packing-houses wastes is the recovery of grease values. This can be accomplished by mechanical skimming operated in conjunction with the clarifier. We have not yet had occasion to design a plant for the ultimate purification of packing-house wastes, but it is suggested that activation of a well-settled effluent will produce good purification and high nitrogen recoveries in the sludge.

Textile Mill, Milk Products, Dyestuff and similar wastes, containing putrescible organic compounds in solution, in general require dosing to effect precipitation and coagulation. Lime and copperas are usually satisfactory as dosing chemicals, but we have found that the slow-settling iron hydrate flocs require relatively large sedimentation units, unless precautions are taken to secure rapid and complete flocculation. It has been found that a certain percentage of finely ground limestone mixed with the milk of lime will give weight to the hydrate flocs and cause more rapid settling. Sufficient time must be allowed in the sedimentation unit to permit the flocs to build

up to their full structure. A well-clarified effluent is amenable to treatment by sand filtration at a high rate for mechanical removal of color.

Acid Mine Waters, Metal Mill Pickling Liquors, etc., are usually treated for the recovery of valuable materials. The process is neutralization with milk of lime or pulverized limestone, followed by continuous sedimentation.

Dorr–Peck Modification of the Activated Sludge Process.

The experimental work which led to the development of this process was undertaken with the idea of evolving an apparatus which would secure high efficiency from the air, in order to reduce the operating costs of this desirable system to a figure comparable to that of other systems in general use.

It was observed that a considerable portion of the air which was diffused into the open type of aëration chamber was inefficiently used to keep the body of sewage in agitation, the object being to produce prolonged contact between air bubbles, activated sludge flocs, and fresh sewage. It appeared as though the agitating effect of the air could be mechanically improved, as many of the bubbles escaping from the open-type aërator pursue a straight-line course from the diffusing tile to the surface, without having done appreciable work, either chemical or mechanical.

This inefficiency is shown by the fact that the normal oxygen-consuming value of the sewage-activated sludge mixture is approximately .05 cu. ft. per gal., while ordinary practice has shown an actual requirement of $1\frac{1}{2}$ cu. ft., or more — thirty times theoretical. A further apparent drawback to the system is the necessity of reactivating a portion of the withdrawn sludge and returning it to the fresh sewage feed in order to continue the biologic cultivation necessary for satisfactory aërobic digestion of the impurities.

The idea was conceived that an aëration unit could be designed to effect self-contained sludge circulation and prolonged contact by utilizing the full mechanical efficiency of the escaping air bubbles in the form of an air lift.

An experimental station was established at Mount Vernon, N. Y., early in 1919, by courtesy of the city authorities, and duplicate aëration units were installed to treat a flow of 45 000 gals. per day of fresh sewage drawn from the lower side of the city bar-screen chamber, containing $\frac{3}{4}$-in. racks.

The work was directed by Mr. C. Lee Peck, director of research and development of our Sanitary Engineering Department. Mr. Peck was responsible for the inception and successful development of the experimental work.

Other vital features affecting the successful aërobic treatment of sewage were developed, which have warranted the adoption of a distinct name for the modification, which has been designated the "Dorr-Peck Process."

A close study of the biologic control and stimulation has indicated the probability of high nitrogen values being recovered in the sludge, by the use of this system. It is our hope that the time is not far distant when municipal sewage may be treated at a profit.

The first unit of the experimental plant was the Dorrco screen, Figs. 3 and 4. This screen is of the rotary drum type, and has been successfully applied to the fine screening of tannery and glue factory waste waters. It is self-cleaning and economical in installation, operation and maintenance.

At the Mount Vernon plant a twill weave brass screen-cloth with 20 meshes to the inch and apertures .017 in. square was used as the screening medium. The screen operated without appreciable attendance, cleaning itself with thoroughness. The average removal of suspended solids over a period of thirty days was 12.2 per cent.

A slight comminuting effect in the screen action resulted in breaking up and passing through the meshes most of the soft solids, which are easily digested in the subsequent activating units. The tough and non-digestible solids were excluded, and since the latter are constituted mainly of non-nitrogeneous material, a corresponding increase in the nitrogen content of the susbequent activated sludge resulted. A further benefit resulting from this comminuting effect was a decrease in the volume of screenings to be disposed of; they are also rendered less offensive to handle.

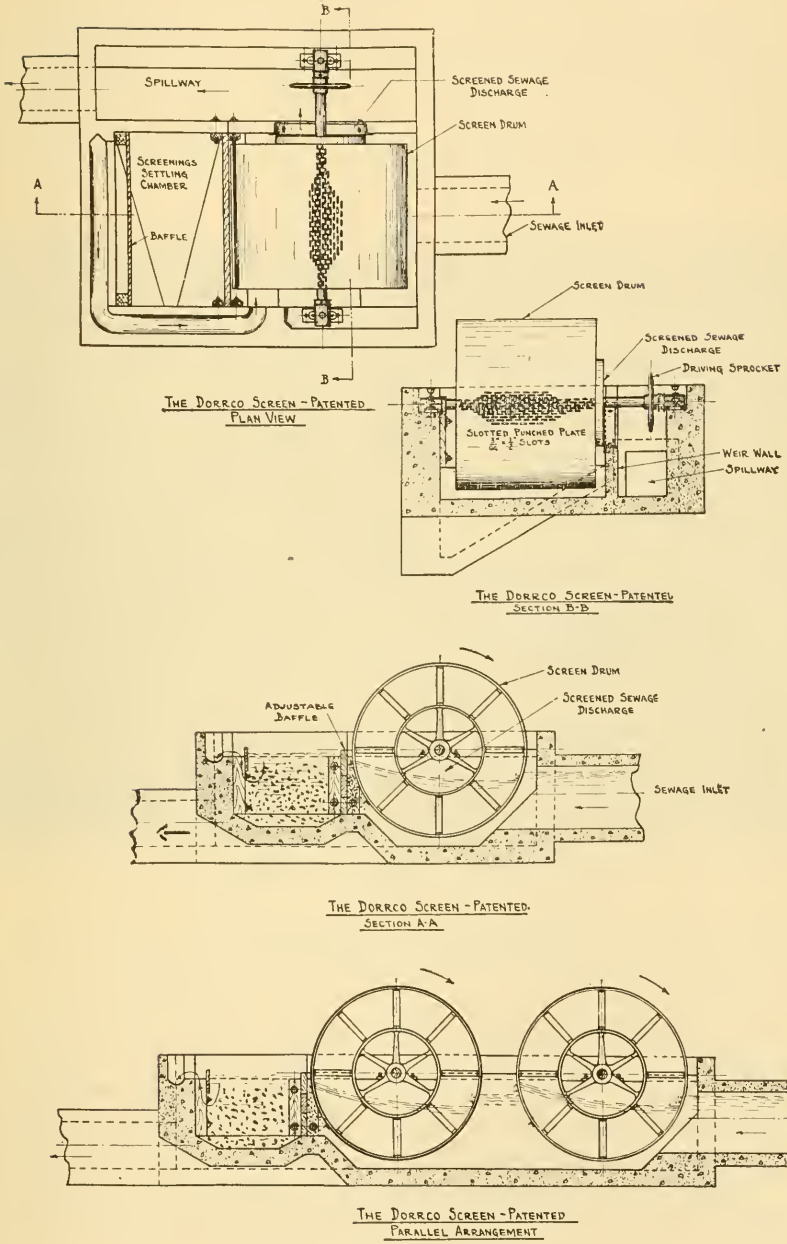


FIG. 3. — DORRCO SCREEN.

The two aëration-sedimentation units in series were designed as shown in Fig. 5. The sewage is delivered at the top of the central downcast well, and is instantly mixed with 20 times its volume of the freshly activated mixture, containing a high concentration of activated sludge solids, which are brought up from the aërating chamber and delivered at the surface from the

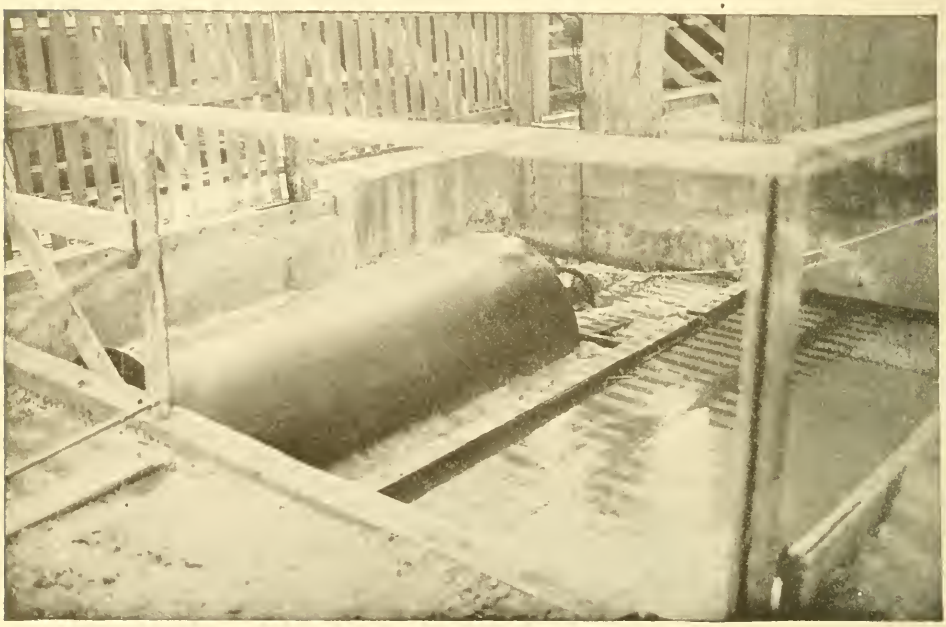


Fig. 4. — Dorrco Screen in Operation.

throat of the air-lift formed by the constricted annular well surrounding the central downcast well.

The cycle is a rapid elevation of the activated mixture from the aërating chamber to the surface, receiving the small proportion of fresh sewage, and a quick passage down again by way of the central downcast well. This action tends to rapid aërobic digestion by actual dilution with the effective medium.

There is a continuous displacement from the circuit of a volume equal to the fresh feed, and this is pushed over into the

outside annular well (which acts as a feed baffle and distributor); thence it flows to the quiescent sedimentation chamber in the upper portion of the tank. The liquor is overflowed peripherally

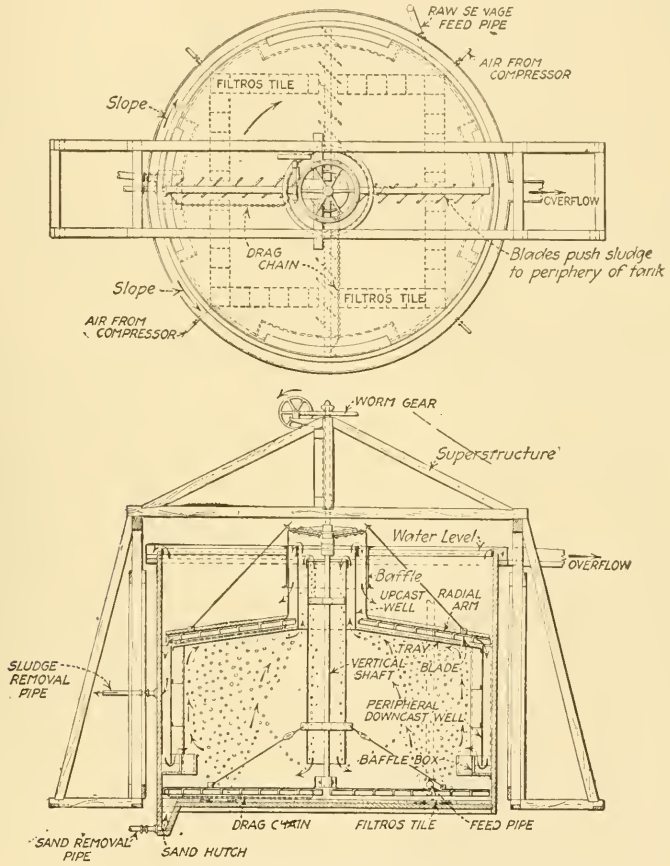


FIG. 5. — THE DORR-PECK ACTIVATED SLUDGE TANK.

from this chamber, the solids settling to the tray bottom, where they are mechanically pushed to the peripheral downcast wells, dropping through to the aëration chamber and entering the circuit again.

A small amount of short-circuiting occurs in the displace-

ment of feed to the sedimentation chamber, partly due to the small-size units used. That is, a small portion of the fresh sewage is pushed direct to this chamber without having passed around the circuit for proper aërobic treatment. For this reason a duplicate unit is placed in series, taking its feed from the peripheral overflow of the first unit. Here the cycle is identical except that 75 per cent. of the oxidation or activation having been effected in the first unit, a correspondingly reduced amount of air is supplied to the second unit.

In order to secure a supply of biologic sludge in the second unit to complete the purification, no sludge is withdrawn from the first unit; it is allowed to build up in the sedimentation chamber and overflow with the partly purified liquor. The only point of sludge withdrawal is from the tray bottom of the second sedimentation chamber, where it is withdrawn as required to keep it from building up and overflowing with the finally purified effluent.

The average air requirement was 0.6 cu. ft. per gal. of sewage treated, maintained uniformly over a period of two months. The detention period through the system ranged from eight to ten hours. A clear, colorless effluent was produced, containing less than 20 p.p.m. of suspended solids, up to 1 p.p.m. of nitrate and nitrite nitrogen, and was stable at least six days to the methylene blue reaction at room temperature. A 90 per cent. removal of bacteria was effected, and the oxygen-consuming power was reduced 80 per cent. The sludge contained 7 to 9 per cent. of nitrogen, on dry basis, expressed as ammonia.

The sewage treated was fresh domestic sewage of the following average composition:

Total solids, 596 parts per million.
Suspended solids, 245 parts per million.
Dissolved solids, 351 parts per million.
Alkalinity, 265 parts per million.
Oxygen consuming power, 154 parts per million.

The average flow treated was 45 000 gals. per day. The two aëration-sedimentation units consisted of cylindrical wood tanks, each 12 ft. in diameter by 11 ft. deep, combined capacity

17 600 gals. Each tank was equipped with a Dorr tray thickener mechanism, the lower arms being equipped with squeegees to move any heavy grit to a peripheral sand hutch, for removal as required. The upper set of arms swept the surface of the tray bottom of the sedimentation compartment, moving the sludge to the peripheral downcast wells for re-circulation, and preventing accumulations of septic masses. In the case of the second unit, the squeezing effect of the plows tended to dewater the sludge to ultimate density for final withdrawal. The thickest sludge removed, however, contained 98.5 per cent. moisture, due chiefly to the small size of the unit which transmitted slight disturbances, interfering with the normal de-watering operation.

The air was supplied by a Nash hydroturbine compressor, and was measured by the Rotary Meter Company's compensating meter, which is so designed as to compensate for any air pressure applied, registering only the actual amount of free air passed. The meter was frequently checked by mercury manometer readings through an orifice, and found accurate. The sewage flow through the plant was recorded over a 90 degree V-notch weir, by a Foxboro recording depth gage.

Filtros tile (Grade E) was used as a diffusing medium, with satisfactory results. No measurable building-up of pressure through clogging was registered during the five months' period of operation. Furthermore, the air supplied by the Nash compressor is quite free from dust, due to a water-washing action which is a part of its operation.

The results are gratifying, and indicate a marked advance in the treatment of sewage by aërobic methods. It is realized that they are not conclusive, by reason of the fact that the local conditions at Mount Vernon might not obtain in another locality, although the analysis indicates a strong municipal sewage.

An experimental Dorr-Peck plant on a 200 000 gal. daily basis is now in operation at Urbana, Ill., under the direction of the Illinois State Water Survey Division. This experimental work was started under the supervision of Col. Edward Bartow. The Corn Products Refining Company is also installing a small experimental unit at its Argo plant, to test its efficiency as com-

pared with other methods. This plant will operate chiefly on the factory waste waters. The experimental work will be directed by the staff of the Sanitary District of Chicago.

DISCUSSION.

Edward Wright.* — Mr. Eagles has brought out several points that are very interesting.

I should like to ask Mr. Eagles particularly about that last statement he made of the 98 per cent. removal of settleable solids from tannery sewage. That's almost 100 per cent. pure. It seems to me a remarkable figure, particularly when producing sludge of 89 per cent. moisture. I don't think it needs qualification, but I should like to ask how long a period that test covered.

Mr. Eagles. — That was taken over a five-day period, when we tested out the plant. At times the removal will drop as low as 50 to 55 per cent. when an excessive volume of sewage comes down, or when they happen to be cleaning the beam house and discharging a high concentration of partially carbonated lime. My statement may be a trifle optimistic, in that the figure was an average over a normal period and did not consider unusual conditions. However, by definition settleable solids are those which can be removed by sedimentation, and it is therefore merely a question of capacity.

When an inquiry is received from an engineer, we give our recommendations as to type and size of units, based on our experience with similar problems. It is a matter we have tried to standardize in some industries such as tanneries, so that knowing the type of tannage, operating period and peak load we can figure fairly closely the required sedimentation capacity and also give approximate figures on the amount of solids which will be removed, the operating expense, etc. We then furnish a quotation on the complete mechanical equipment required for the installation, or such part of it as we are asked to supply.

The only guarantees we will make, under normal conditions, are as to mechanical operation of the unit, and in some cases removal of settleable solids, — where we are thoroughly familiar

* Assistant Engineer, State Department of Health, 141 State House, Boston, Mass.

with the kind of material to be treated. But it is not practicable except under unusual conditions to guarantee anything other than the mechanical efficiency of the equipment.

With reference to the slope of $1\frac{3}{4}$ ins. to the foot in the Dorr thickener tanks, would say that it is an arbitrary figure, and we have had our casting patterns made on that basis. We have, however, designed equipment to operate with as low as $\frac{1}{2}$ in. to the foot, and get the same results. It means a difference in the time which a particle will require to pass from the periphery to the center. There are two factors entering into it, — first, flow action by reason of the slope, or gravity; and, second, mechanical action of the plows; and if it is essential to get it into the center in quick time, or if it is material like metallurgical slime that does not readily flow, then the slope is beneficial. It is our intention, however, to experiment with flat-bottom tanks, because the plows will apparently move the material equally well.

As to the advantage which the Dorr thickener has over the Pfidler spiral which was developed in England some years ago, I believe the trouble with that mechanism was that it tried to push a whole bed of sludge at once with a single spiral arm. With the short plows of the Dorr mechanism the work is done in small bits; in other words, we get the helical effect without pushing the entire sludge body. With the helical apparatus it was apparently found difficult to get a mechanism that would stand up under the strain, and the power requirements were high.

Mr. Marston has referred to a circular tank in which the wastes were discharged into the top of the tank through a portion of the periphery, flowing thence in a fan-shaped path to the circumferential weir occupying the remainder of the periphery.

In that particular installation we had a very shallow tank to start with, and were afraid with central feed we would have a pile of sludge at the center and the feed coming down would disturb the sludge pile and tend to stir it up, so we introduced the feed through one portion of the periphery and baffled it out towards the center of the basin. This gives fairly good results, but is apparently not as positive as the central feed. There is some short-circuiting.

With reference to breakage of equipment, we had some trouble at the start on account of using too light mechanisms on this type of work, particularly one case at a tannery where we first installed a small 25-ft.-diameter test clarifier. The sludge appeared to be very light and flocculent, almost like iron hydrate flocs, and apparently there would be no more strain on the mechanism than with ordinary chemical work. As a matter of fact, however, the sludge packed so dense that it put an extraordinary strain on the mechanism, and on the spider casting at the bottom, which supports the arms. This is the breaking member of the mechanism, if any — and it broke in that particular installation. We now use heavier mechanisms throughout, and also heavier superstructures to overcome any side sway. I might add that the clarifiers are equipped with an automatic overload alarm which registers the torsion on the central shaft and rings a bell in the superintendent's office to indicate that it is time to pump some sludge to relieve the load.

With certain material it is entirely feasible to use an existing square basin without closing in the corners and without sloping the bottom, because the mechanism will make its own bed; but that applies chiefly to granular substances. In the particular case you speak of, the sludge, being non-homogeneous, tended to build up in the corners, and slough off, causing a sudden excessive strain on the mechanism. We therefore closed up the corners and sloped up the bottom. The proper slope is made by spreading on a thin grout and rotating the mechanism, the plows making their own bed. The sloping bottom is particularly desirable in the case of septic sludge, otherwise there may be an accumulation which will generate gases and interfere with settling. In a number of cases we have used a cinder bottom with a tamped clay as grout.

Harrison P. Eddy.* — I do not wish to intrude on the discussions and have the effect of shutting off questions to Mr. Eagles, but assuming that nearly all the questions have been asked it may be of interest to the members to hear a little about some of the experiences with the Dorr Company's mechanisms which have come under my observation.

* Of Metcalf & Eddy, 14 Beacon Street, Boston, Mass.

You may or may not be familiar with the experimental work which has been done at Milwaukee. Dating back at least as far as 1917, one of the Dorr thickeners, so-called locally at least, has been in use. Subsequently four tanks were equipped with the same kind of mechanism. If I remember correctly, two of the tanks are about 8 ft. square and the other two about 11 ft. square at the top. These tanks have been used for removing from the aërated sewage, obtained in the activated sludge process of treatment, such sludge as will readily settle. In these experiments I think I am safe in saying that the proportion of suspended matter which has been removed has averaged about 95 per cent. It has not been found practicable, under those conditions, to concentrate the sludge below 97 per cent. water or 3 per cent. solids. On the average the sludge has been somewhat less dense than that, perhaps in the neighborhood of $2\frac{1}{2}$ per cent. solids. The "thickeners," however, have served a useful purpose in scraping the sludge continuously and promptly to the discharge pipes.

In other places, tanks with conical bottoms or pyramidal bottoms have been installed, and similar results have been obtained, without the use of moving machinery.

One of the problems, with which the engineering staff at Milwaukee is struggling, is how to build a series of tanks to accommodate about 85 m.g.d. and equip them with these thickeners. Obviously, if the efficiency of sedimentation — that is, the quantitative efficiency — depends upon the quantity of sewage passed through the tanks per square foot of area, the rectangular tank is the more economical other things being equal. It is also apparent that a very deep tank is not required. As a matter of fact, designs are being studied on the basis of a tank 15 ft. in depth. The problem is so to design the tank that it will be rectangular near the top and round at the bottom. The difficulty comes in the rate of slope of the sides, and still more with the rate of slope of the corners of the tank. For example, in the case of a very large tank, — one which has been studied is 75 ft. square at the top, — if the corners are drawn to a circle at a depth of 15 ft. a relatively flat, warped surface is required, in which the sludge is likely to collect and in warm weather to decompose, with unfavorable results.

Another very interesting problem is that at Syracuse, where Mr. Glenn D. Holmes, chief engineer of the Intercepting Sewer Board, proposes to install shallow, round tanks for the removal of suspended matter by sedimentation — these tanks to be equipped with the Dorr thickener. One problem has been how to dispose of the sludge. The sludge from an ordinary sedimentation tank is not a particularly easy material to dispose of, because of its peculiarly objectionable condition. At Syracuse Mr. Holmes's plan is to pump this sludge from the treatment plant a distance of several miles — two at least — to the point of discharge of the liquid wastes from the Solvay Process Company's plant. These wastes contain a very large quantity of suspended matter from manufacture of alkalies. It is present in sufficient quantity, when mixed with the sludge of the sewage of the entire city of Syracuse, to effectually bury the sewage solids when spread out in lagoons and the suspended matter is allowed to settle. The Solvay Process Company at present pumps its wastes into lagoons, allowing the relatively clear water to overflow the dikes into Onondaga Lake, the solids simply building up the land. It is a unique opportunity to be able to dispose of suspended solids from sewage by mixing them with wastes which will effectually bury them, so that they will be but a small percentage of the entire accumulation.

I was fortunate enough, through the courtesy of the Dorr Company, to have the privilege, in company with Mr. T. C. Hatton, of Milwaukee, of visiting the Mount Vernon plant, and saw the plant which Mr. Eagles has so clearly described and beautifully illustrated by his model in the other room. I was very much impressed and pleased with the operation of the screen which was there in use. There are problems with that screen, as there are with every other mechanical screen or device, but it is certainly a clever scheme by which they utilize the centrifugal force, imparted to the sewage within the screen, to wash the solids off of the screen on the outside. That is accomplished, as Mr. Eagles has explained, by raising the level of the sewage within the screen slightly above that of the sewage without the screen; and, as far as I could see at the Mount Vernon plant, the screen was being effectually cleaned. There was some doubt

expressed at that time about the means of disposing of the screenings. In sewage treatment we have been trying to get away as much as possible from liquid sludge, and one of the arguments in favor of screening has generally been that solids come from the screen in a drained condition. With the Dorrco screen they are in the form of sludge, and that, I believe, will constitute one of the problems to be encountered with the use of this screen in some cases.

The aëration tank for carrying out the activated sludge treatment at Mount Vernon on the day of my visit was producing a very satisfactory effluent. The sewage was a strictly domestic sewage — one ordinarily easy to treat — and the consumption of air was low as compared with that which has been used in some other cases. Too much weight, however, should not be given to a comparison of the figures, without intimate knowledge of actual operating conditions. For instance, I suspect that .6 cu. ft. of air per gallon of Mount Vernon sewage might not be any less per unit of work done than $1\frac{1}{2}$ cu. ft. per gallon of sewage such as that treated at Milwaukee. Do not take this statement as a result of comparison of analyses or conditions, however. It is simply a surmise. I mention it simply by way of caution. It isn't possible to intelligently compare estimates of the quantity of air used in the abstract without knowing a great deal about the local conditions.

I think we are very much indebted to Mr. Eagles for his kindness in coming to talk to us, and while we realize that he represents a company which is in a commercial business, nevertheless we must give to him and to the company which he represents a great deal of credit for having done some really original work in the field of sewage treatment.

Robert Spurr Weston.* — The first Dorr thickener or clarifier I remember was at Colorado Springs, used for separating sludges from ore suspensions in the cyanide process. There were several sanitary engineers present, and one of them remarked that it would be well if such an efficient device could be applied to sewage. That desire has been realized.

* Of Weston & Sampson, 14 Beacon Street, Boston, Mass.

That the flat tank is a most efficient subsiding device is no new idea. All who are familiar with Allen Hazen's paper * will remember that he discusses the efficiency of an assumed basin in which the water passing through it flows in a thin layer while the water below it remains quiet or nearly so.

The most valuable characteristic of the Dorr clarifier, in the speaker's opinion, is its sludge-handling mechanism. This is particularly valuable in cases where industrial wastes producing large volumes of sludge are treated. In such cases this sludge accumulates so rapidly that it is often beyond the power of the management of the industry to properly care for the subsiding basins. The tank fills with sludge and becomes useless for its purpose. On the other hand, the Dorr device almost compels proper attention. The sludge is discharged continuously, and must be hauled away. The clarifiers which I have seen at Peabody are particularly successful in this particular.

I think we are very much indebted to the speaker for this excellent paper, and to the Dorr Company, which not only has produced ingenious devices applicable to the uses of sanitary engineers but is maintaining a fine research laboratory for sewage investigations, the findings of which it is using both for its own and the general benefit.

* "On Sedimentation." — Trans. Am. Soc. C. E., *53*, 47.

MEMOIR OF DECEASED MEMBER.

JOHN CHARLES OLMSTED. *

JOHN CHARLES OLMSTED was one of the leaders in the comparatively new profession of landscape architecture, and with his associates designed the greater portion of the public parks of America.

His parents were Dr. John Hull Olmsted and Mary Cleveland (Perkins) Olmsted, of Connecticut, who were traveling abroad when their son was born, September 14, 1852, in Geneva, Switzerland. His male ancestors were among the original settlers of New England, coming from James Olmsted, of Cambridge, Mass., 1632.

The young son was a delicate child with weak eyes, and his early education was largely obtained at home under governesses, and later at private school.

Dr. Olmsted died in 1857, and his widow married in 1859 her brother-in-law, Frederick Law Olmsted, who adopted his nephew and stepson as his son, although the latter developed the practice of calling him "uncle."

While a school-boy, young Olmsted spent his summers of 1869 and 1871 with the United States Geological Survey in the Rocky Mountains, on the survey of the 40th parallel and in making natural history collections.

It having been decided that he should study medicine, he was graduated Ph.B., Yale Sheffield Scientific School, 1875; but his love of nature and the association with his uncle and stepfather drew him at once into landscape architecture, of which the older man was then, as later, the leading and most successful practitioner.

The young man was always studiously inclined, and after graduation studied architecture, designing, drafting, landscape gardening, arboriculture, horticulture, etc., with some of the best men in each line, and also traveled abroad making observations and accumulating notes and photographs. He also studied in

* Memoir prepared by Henry F. Bryant and Edward W. Howe.

detail the many works of his stepfather and Calvert Vaux, who were associated in the design and construction of the parks of New York, Brooklyn, Buffalo and elsewhere.

Young Olmsted was taken into partial partnership with his stepfather in 1878, giving the major part of his time to the designing and drafting details of the business, and became full partner in 1884. The older man broke down and retired in 1895, and the firm became known as Olmsted Brothers by including the brother, F. L. Olmsted, Jr.

Mr. John C. Olmsted's work is inextricably connected with that of the firm during his forty-two years of active participation. This work, conducted in the office on Warren Street, Brookline, was mainly concerned with public parks, towns and suburbs, and the grounds of institutions, schools and private residences, and naturally included all features of construction. It was constantly, however, a matter of design and supervision and was seldom permitted to include land surveys or building design or construction.

During this period designs were made for more than a thousand public grounds and private places throughout the country.

The work of designing and providing the great park system of Boston, and the Metropolitan Park System surrounding it, is the one in which our members knew him best, and is one that enjoyed his personal attention throughout.

It is needless to recite the names of the many works which have been designed or executed under his eye, but they include the parks of nearly or quite all the large cities which, of course, includes the grounds of our several world fairs.

Mr. Olmsted was a member of many professional and other organizations, in some of which he took a very active part, being president of the American Society of Landscape Architects for some time. He joined the Boston Society of Civil Engineers in 1887, and retained his membership until his death. While seldom seen at our meetings or on our excursions he followed our professional papers closely and showed by his frequent comments that he was interested in and familiar with Society affairs.

Mr. Olmsted was a somewhat reticent, retiring man, of intense convictions based on the highest principles of life and

art. He was broad in his religious views, independent in politics, and was forward-looking on the social questions of the day.

However much his insistence on what he considered best may have disturbed his clients, no one ever questioned his singleness of purpose or the high quality of his plans.

With a large circle of friends and acquaintances, his industry and his retiring habits prevented making many intimate friendships.

On January 18, 1899, Mr. Olmsted married Sophie Buckland White, of Brookline, and had two children, who, with his wife, survive him.

Never a robust man, he kept himself in good working form in college and in business by regular exercise and recreation. Gymnastics, bicycling, yachting, and, latterly, walking, he believed to be essential to health.

For the last few years failing health compelled a gradual withdrawal from business, and for many weary months he was confined to his bed.

Mr. Olmsted died February 24, 1920, leaving behind a record of industry and accomplishment worthy of emulation equally as an engineer an artist and a man.

Vol. VII DECEMBER, 1920 No. 10

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PROCEEDINGS

PAPER IN THIS NUMBER

"Wood and Concrete Piling. An Informal Discussion."

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Contributors are hereby notified that proof will not be submitted to them for examination unless requested before the 10th of the month preceding the month of publication.

MINUTES OF MEETINGS.

BOSTON, November 17, 1920. — A regular meeting of the Boston Society of Civil Engineers was held this evening at Chipman Hall, Tremont Temple, and was called to order at 8 o'clock by the President, Frank A. Barbour.

There were 195 members and visitors present.

The record of the last meeting was read and approved.

The Secretary reported for the Board of Government the election to membership of the following candidates in the grades named: As members — Messrs. Frank J. McCann and C. Hale Sutherland; and as a junior — Mr. John Lucas.

The Secretary also reported for the Board of Government the result of the questionnaire on the Report of the Committee on Compensation of Engineers, sent out by vote of the Society at its September meeting, as follows:

Total number replies received	325
Number not signed	14
Total number counted	311

In answer to the first question:

" Do you agree with the recommendations of the Committee on Compensation of Engineers that the Society should endorse the schedule of salaries approved by Engineering Council? "

Number answering " Yes "	273
Number answering " No "	23
Blanks	15

The Schedule of Engineering Council is as follows:

Grade.	Total Years' Experience Required to Qualify: With Professional Degree.	Without Professional Degree.	Salary Range: Minimum.	Maximum.
8 — Junior		0	$1 080	$1 560
7 — Aid		2	1 680	2 400
6 — Senior Aid		5	2 520	3 240
5 — Junior Assistant Engineer	0	4	1 620	2 580
4 — Assistant Engineer	2	6	2 700	4 140
3 — Senior Assistant Engineer	5	9	4 320	5 760
2 — Engineer	8	12	5 940	No limit
2 — Chief Engineer	12	16	8 100	No limit

In answer to the second question:

" Do you agree with the report of the Committee on Compensation of Engineers that the preceding schedule should apply equally to public and private service? "

Number answering " Yes "	264
Number answering " No "	38
Blanks	9

The President stated that the December meeting would be a joint meeting in which the Boston sections of the American Society of Mechanical Engineers and of the American Institute of Electrical Engineers would participate, and it would be a convenience to these sections if the meeting were held on Friday, December 17, instead of December 15, the regular date for holding our next meeting.

On motion of Mr. Weston, it was voted to advance the date of the next meeting from December 15 to December 17.

The President then called on Past President John R. Freeman, who gave a most interesting talk on "Some Engineering Problems of China and the Far East."

The talk was illustrated by a large number of lantern slides, some of them beautifully colored.

A short discussion followed Mr. Freeman's talk, in which Past President Desmond FitzGerald spoke of some of his observations in China.

At 10.15 Vice-President Weston, who was in the chair, declared the meeting adjourned.

S. E. TINKHAM, *Secretary.*

BOSTON, MASS., October 6, 1920. — A meeting of the Sanitary Section of the Boston Society of Civil Engineers was held this evening in the Society Rooms, Tremont Temple. The meeting was called to order at 8.00 P.M., by Chairman Edward Wright.

The records of the annual meeting were read and approved as printed in the JOURNAL.

The chairman stated that he had appointed Messrs. Frank A. Marston and H. E. Holmes on the Committee on Inverted Siphons.

The chairman then introduced Mr. R. H. Eagles, chemical engineer for the Dorr Company, who spoke on "The Treatment of Sewage and Trade Wastes by Mechanical Methods, with Special Reference to the Dorr Systems" and "The Dorr-Peck Modification of the Activated Sludge Process of Sewage Treatment."

Mr. Eagles described, in detail, the Dorr Systems and the method of operation, and spoke particularly on the experimental work at Mt. Vernon, N. Y.

The subject was discussed by H. P. Eddy, R. S. Weston, F. A. Barbour, Leonard Metcalf, A. L. Fales and others.

On motion of Mr. Marston, a rising vote of thanks was given to Mr. Eagles for his kindness in speaking to the section.

The talk was illustrated by means of the reflectoscope.

A miniature Dorrco screen, Dorr sewage clarifier and Dorr-

Peck aërator, operated by an electric motor, were exhibited in the main library. This apparatus was furnished by the Dorr Company.

The meeting adjourned at 9.40.

Members present, 41.

JOHN P. WENTWORTH, *Clerk.*

BOSTON, MASS., November 3, 1920. — A regular meeting of the Sanitary Section was called to order at 8.00 P.M. this evening, by Chairman Edward Wright, in Chipman Hall, Tremont Temple.

There being no objection, the minutes of the previous meeting were filed without being read. The chairman announced a hearing upon a proposed revision of plumbing regulations, to be held at the State House at 4 P.M., November 9, 1920, in which it has been urged that engineers interest themselves. It was also announced that Mr. T. Chalkley Hatton, chief engineer, Milwaukee Sewerage Commission, would address a special meeting of the Section, Wednesday evening, November 10, upon the status of the activated sludge plans of Milwaukee.

Prof. G. C. Whipple was then introduced and gave an account of his recent experiences in Europe as director of the Department of Sanitation of the League of Red Cross Societies. He described the development of the League, outlined his impressions of Geneva, its headquarters, which is also the "capital" of the League of Nations, and discussed conditions, both political and sanitary, as he found them in Roumania. His audience of 62 included many ladies who came as guests of members.

The meeting adjourned at 9.20.

A. L. SHAW, *Acting Clerk.*

BOSTON, October, 6 1920. — A meeting of the Designers Section of the Boston Society of Civil Engineers was called to order at 6.20 P.M. by Chairman R. W. Horne.

After the minutes of the previous meeting were read and accepted, it was moved, seconded and carried, that the Section

concur in the modification of the By-Laws required by the Board of Government. The By-Laws therefore stand approved and accepted as published in the June, 1920, JOURNAL.

Mr. Charles R. Gow then reviewed the history of " Borings " from the earliest method of sounding with rods to the modern use of wash and core-borings apparatus. His talk was followed with great interest by the 27 members and guests present, and covered the subject in a very complete manner.

Mr John T. Scully followed, with an account of some of his experiences in investigating foundations by means of borings, including some novel methods employed in the earlier days of the art.

General discussion followed, and the meeting was adjourned at 8.20. ARTHUR L. SHAW, *Clerk*.

BOSTON, MASS., November 11, 1920. — A meeting of the Designers Section was called to order in the Society Library, with 27 present and Chairman Horne presiding.

After the minutes of the previous meeting were read and approved, the first speaker, Mr. John H. Hession, was introduced and outlined the history of waterproofing and described the various methods that have been employed. Mr. J. Francis Travers, Jr., then made a plea for greater coöperation between architects or engineers and the waterproofing contractor, urging the desirability of consulting the latter in the early stages of design and of giving him a free hand to get results in his own way on the job.

Vice-Chairman Rice emphasized the advantage of carefully proportioning the aggregates of a concrete, thus increasing the density and securing a measure of waterproofing without the introduction of outside agents. He also mentioned the growing use of fine ground cement as a means of securing greater density and reducing the inert content of the cement.

Mr. Edward S. Larned, who was to have spoken, was unable to be present, but sent a letter discussing points similar in general to those covered by Mr. Rice.

The meeting adjourned at 8.00 P.M., after further discussion by several members. A. L. SHAW, *Clerk*.

APPLICATIONS FOR MEMBERSHIP.

[December 15, 1920.]

THE By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

CHASE, WILLIAM HENRY, New Bedford, Mass. (Age 44, b. Taunton, Mass.) 1895–1902, chainman, rodman and transitman on municipal work, city of Bedford; 1902-3, inspector and draftsman on textile mill construction, with W. F. Henry, mill engineer; Fall River: 1903-5, transitman on railroad location, and assistant engineer on track and bridge construction, Lake Shore & Michigan Southern Ry Co.; 1905-6, inspector in station construction, and assistant engineer on track relocation and electrification for New York Central R.R., New York, N. Y.; 1906-9, assistant engineer and later superintendent of construction, with Snare & Triest Co., New York, on building of foundation and approach of the 184th St. highway bridge, New York City, and Long Island approach to Queensboro Bridge; 1909, superintendent of construction, Standard Construction Co., Chicago; and 1909 to date, assistant engineer, Engineering Department, City of New Bedford, Mass. Refers to A. B. Drake, H. E. Holmes, G. H. Nye, H. F. Sawtelle, C. L. Wade and W. F. Williams.

CLARK, THEODORE PARKER, Winchester, Mass. (Age 39, b. Cambridge, Mass.) Educated in the public schools of Cambridge; graduate of Rindge Technical School, 1901; and at Northeastern College, 1914–15, civil engineering course. From Dec., 1901, to April, 1904, engaged in mechanical and electrical work; May, 1904 ,to May, 1912, with Street Department of Cambridge as clerk and foreman in charge of all branches of municipal work; May, 1912, to April, 1913, superintendent and engineer of Street Dept., Needham, Mass.; April to July, 1913, instructor for Barrett Co., on use of tar for road work;

July, 1913, to June, 1915, Cambridge Street Dept., as supervisor of construction; June, 1915, to date, superintendent of Dept. of Highways, Winchester, Mass. Refers to A. W. Dean, L. M. Hastings, H. V. Macksey, C. R. Main, R. W. Pond and D. W. Pratt.

Garvin, Francis Arthur, Brighton, Mass. (Age 46, b. Brighton, Mass.) Educated in the Boston schools, and special engineering courses in correspondence schools and private tutoring. From May, 1896, to October, 1903, rodman and instrument man, Street Laying-Out Dept., Boston, Mass.; October, 1903, to date, draftsman and instrument man in charge of party for precise leveling and construction work on sewer service, City of Boston. Refers to T. F. Bowes, C. S. Drake, E. F. Murphy, J. E. L. Monaghan, E. H. Rogers and F. O. Whitney.

Harvey, James Francis, Dorchester, Mass. (Age 23, b. South Boston, Mass.) Studied at Franklin Union for three years in heating and ventilating, practical science, mensuration shop arithmetic. With French & Hubbard two years, 1914–16, as draftsman; with Monks & Johnson six months as draftsman; six months with Hope Engineering Co., and from September, 1919, to date, draftsman with Lockwood, Greene & Co. Refers to W. W. Bigelow, M. J. O'Brien, E. P. Rankin, H. F. Sawtelle, H. C. Thomas and J. F. Wilber.

Hinds, James, Winchester, Mass. (Age 50, b. Winchester, Mass.) Has been engaged in engineering for the Town of Winchester since 1895, and has been its town engineer since 1903. His work has been the municipal engineering work of the town, sewerage, storm-water drainage, street construction, etc. Refers to H. K. Barrows, A. W. Dean, C. T.Main and D. W. Pratt.

Holbrook, Parker, Winchester, Mass. (Age 32, b. Malden, Mass.) High-school education. Has had twelve years' experience in surveying and municipal engineering. At present, assistant engineer with Town of Winchester. Refers to H. K. Barrows, C. H. Gannett, C. T. Main, D. W. Pratt, R. W. Pond and F. E. Sherry.

Keith, Scott, Newton, Mass. (Age 22, b. Newton, Mass.) Graduate in civil engineering, Mass. Institute of Technology, 1918. Draftsman in Hull Dept. at Cramp Bros., Ship and Engine Bldg. Co., Philadelphia, Pa., Jan. to June, 1919; assistant civil engineering department, M. I. T., Aug., 1919, to June, 1920; at present on engineering staff of Metcalf & Eddy. Refers to H. K. Barrows, F. A. Marston, Leonard Metcalf, Dwight Porter, C. W. Sherman and C. M. Spofford.

Krigger, Anselmo, Cambridge, Mass. (Age 28, b. New York City.) Graduate of Mass. Institute of Technology, degree of B.S., in civil engineering, in 1917. From Sept., 1917, to date, with Mass. Dept. of Public Works, Division of Highways, with the exception of four months in U. S. Army. Has been resident engineer on highway construction, and is at present assistant engineer with the Public Works Department. Refers to A. B. Appleton, A. P. Rice, R. A. Vesper and W. N. Wade.

Leary, Charles Arthur, Swampscott, Mass. (Age 41, b. Waltham, Mass.) Three years at Mass. Institute of Technology, class of 1900. Engaged

in mining engineering, Spangler, Pa., 1901–6; with G. M. Bryne Co., general contractors, Boston, 1907–8; with Boston Elevated Railway on engineering surface lines, 1909–10; engineer, Public Works Dept., Peabody, Mass., 1911–12; engineer, Mass. Bonding & Insurance Co., Boston, 1918–19, and at present superintendent of the Charles R. Gow Co. Refers to C. R. Gow, R. W. Horne, G. L. Myrick and J. W. Rollins.

Leland, Franklin Edward, Newton, Mass. (Age 30, b. Ashfield, Mass.) Graduate, Sanderson Academy, Ashfield, 1907. In 1907 engaged in land surveying at Greenfield, Mass.; from 1907 to 1914 draftsman as follows: Greenfield Tap & Die Co., 1907–8; Chase Turbine Mfg. Co., Orange, Mass., 1908–9; Kilham & Hopkins, architects, Boston, 1910–11; Allen & Collens, architects, Boston, 1912–14; with Boston & Albany R.R., as estimator, valuation department, 1915; Stone & Webster, Inc., as designer, 1915–18; Fay, Spofford & Thorndike, as designer, 1918–19; with Aberthaw Construction Co., as designer, 1919; and at present resident engineer and designer with Fay, Spofford & Thorndike. Specialist in design of reinforced concrete. Refers to C. R. Berry, B. A. Bowman, L. F. Cutter, H. A. Gray, W. F. Pike and W. D. Trask.

MacLeay, Francis Roderick, Barre, Vt. (Age 24, b. Barre, Vt.) Educated in schools of native town and in civil engineering courses of one year at Franklin Union, Boston, and three years at Northeastern College, Boston, also one year at Suffolk Law School, Boston. From July, 1915, to Aug., 1916, draftsman with C. W. McMillan & Sons, Barre, Vt.; Aug., 1916, to Nov., 1917, draftsman with Cook, Watkins & Co., Boston; Nov., 1917, to March, 1918, plant draftsman, Western Union Telegraph Co., Boston; May to Sept., 1918, party chief with F. F. Jonsberg Co., Boston; September, 1918, to Jan., 1919, superintendent for C. W. McMillan & Sons, Barre, Vt.; Jan. to March, 1919, on public service appraisal, F. F. Jonsberg Co.; March to Oct., 1919, draftsman and party chief, Massachusetts Department of Public Works, Highway Division, and at present head of the mathematical department, Goddard Seminary, Barre, Vt. Refers to A. W. Dean, F. F. Jonsberg, A. M. Lovis, C. H. Restall, A. P. Rice, W. N. Wade.

Martin, Albert George, Milton, Mass. (Age 23, b. Brookline, Mass.) Graduate of Milton High School, 1917, and of Wentworth Institute in 1920. Summer of 1919, plan clerk for Lockwood, Greene & Co., and in 1917, surveying for W. W. Churchill, Milton, Mass. At present draftsman with Lockwood, Greene & Co. Refers to W. W. Bigelow, M. J. O'Brien, E. P. Rankin, H. F. Sawtelle, H. C. Thomas and H. A. Varney.

Newcomb, George Holland, Quincy, Mass. (Age 34, b. Newburyport, Mass.) Graduate of Quincy High School in 1903, and post-graduate in 1904. From July, 1904, to Feb., 1905, in charge of plans, hull drafting room, Fore River Shipbuilding Co.; May, 1905, to Feb., 1906, rodman with Whitman & Howard, Boston, and from May, 1906, to date, with E. W. Branch, Boston and Quincy, on general engineering and surveying, except from Aug., 1917, to April, 1919, with the 101st U. S. Engineers, Co. B. Refers to E. W. Branch, Perry Lawton, E. C. Sargent, F. E. Tupper, H. L. White and R. H. Whitney.

Travers, Joseph Francis, Jr., Cambridge, Mass. (Age 40, b. Boston, Mass.) Educated in the public schools of Boston, including Mechanic Arts High School. Ten years' experience as concrete engineer on waterproofing construction and design. Has carried through successfully the waterproofing of cellars, basements, tunnels, swimming pools, boiler-room tanks, sewers, dams, motor pits and various other works. Has been with the National Waterproofing Co. for the past ten years, and has had charge of all the engineering work. Refers to E. F. Allbright, H. F. Bryant, Benj. Fox, F. F. Jonsberg, J. T. Scully and H. C. Shiels.

White, David Joseph, Quincy, Mass. (Age 37, b. Quincy, Mass.) Educated in the public schools of Quincy and evening class in mechanical engineering at the Boston Y. M. C. A. From 1901 to 1904, draftsman and foreman, Quincy Quarries Co.; 1904 to 1909, general foreman and inspector with Ryan-Parker Construction Co., Stonington, Me., during the construction of Riverside Drive, New York, and steel and masonry piers for Manhattan Bridge, New York; 1910, in charge of cofferdam work for sea-wall of Ayer Mill in Merrimack River at Lawrence, Mass.; 1911, estimator with Cashman & Sons Co., Quincy, Mass., during the construction of Sandy Bay Breakwater, and various railroad and bridge contracts; and since 1911, with the Bay State Dredging & Contracting Co., and acting as general manager of that company; in 1918 served also as New England member of Emergency Dredging Committee, who had in charge the entire dredging program of the Government during the war. Refers to H. S. Adams, C. R. Gow, F. W. Hodgdon, C. H. Rogers, J. W. Rollins and W. F. Williams.

Woods, Walter Augustine, Somerville, Mass. (Age 24, b. Somerville Mass.) Student for two years at Lowell Institute, 1914–16, building course; one year at Franklin Union, 1916; one year I. C. S. course in railroad engineering, 1916–17; two years' course with Alexander Hamilton Institute on "Modern Business." Began work in 1913 with H. P. Converse & Co., as helper in drafting room; for one and a half months in 1914, on gas main plans for Arlington Gas Light Co.; in 1915 again with Converse & Co. in Baltimore as concrete form inspector, and from 1915 to date with the B. & M. R.R. as chainman, rodman, draftsman, water supervisor, inspector of bridges and buildings, etc., and at present assistant engineer on Terminal Division. Refers to E. P. Bliss, N. C. Burrill, S. P. Coffin, R. H. Parke, J. J. Rourke and S. E. Tinkham.

Wright, Frank Vernon, Salem, Mass. (Age 30, b. Hamilton, Mass.) Graduate of Connecticut State College in 1913, and since that date has been engaged in civil engineering work. This work has been, five and a half years on railroad engineering, six months on hydro-electric work, and the remainder on general engineering. For the last four years has been in charge of party on both surveys and construction; in 1913–14 on general engineering and road construction in Jamaica with the United Fruit Co.; 1915–16 with the B. & M. R.R.; 1916–17 with the Central R.R. of New York and the N. Y., N. H. & H. R.R.; 1917–18 with French & Hubbard and B. &. M. R.R.; and since July, 1918, with the B. &. A. R.R. as chief of party in charge of surveys relative to encroachments, land court and right-of-way construction. Refers to L. G. Brackett, Allen Curtis, T. P. Perkins and F. B. Rowell.

EMPLOYMENT BUREAU.

THE Board of Government maintains an employment bureau for the Society, to be a medium for securing positions for its members and applicants for membership, and also for furnishing employees to members and others desiring men capable of filling responsible positions.

At the Society room two lists are kept on file, one of positions available and the other of men available, giving in each case detailed information in relation thereto.

MEN AVAILABLE.

514. Age 35. Two and one-half years' course at University of Maine in civil engineering. Experience, has acted as inspector for six months on sidewalk, sewer and paving construction; eighteen months as job engineer on various kinds of work; one year as assistant engineer on layout of water works, sewers, railroads and streets; six months as examiner of claims. Desires position as resident engineer on reinforced concrete building or water-front work.

516. Age 22. Graduate of technical college, studied in architectural engineering. Has had experience as rodman and draftsman. Desires position as transitman or assistant engineer.

517. Age 29. Has B.S. in civil engineering. Two years' experience on railroad work; two years in charge of construction work; one year superintendent of shop; nearly two years Corps of Engineers, U. S. Army. Desires position as office engineer.

518. Age 34. Graduate in mechanical and electrical engineering. Experience, two years machine and forge shops; four years drafting; two years chief draftsman; two years specification and sales; two years production officer (Capt.), U. S. Army; three years industrial engineering and management in manufacture of electric wire and cable. Desires position as industrial engineer or factory executive.

519. Age 64. Public-school education. Thirty-five years' experience as inspector on sewer construction, bridge and water reservoirs. Desires position as inspector.

LIST OF MEMBERS

ADDITIONS.

ETTER, HAROLD P. 512 Commonwealth Ave., Boston, Mass.
HARSCH, ERWIN 65 Mt. Auburn St., Cambridge, Mass.
MCCANN, FRANK J. 135 Aiken Ave., Lowell, Mass.
MORGAN, GEORGE B. 13 Waterhouse St., Cambridge 38, Mass.
SUTHERLAND, C. HALE Mass. Inst. of Tech., Cambridge, Mass.

CHANGES OF ADDRESS.

BROWN, ALBERT F. 36 Maxwell St., Boston 34, Mass.
CRANE, JACOB L., Jr., Robinson Hall, Harvard University, Cambridge, Mass.
FALKENBERG, J. J. 105 Gainsboro St., Suite 4, Boston, Mass.
FULLER, W. B 219 So. Central Ave., Eagle Rock, Calif.
LAWRENCE, BEARDSLEY Box 268, Sharon, Mass.
MAWNEY, R. W. 27 Park St., Room 4, Attleboro, Mass.
MORSE, W. F. 10074 Keenan Park, Cleveland, Ohio
PARKE, ROBERT H. 17 Thomas St., Fitchburg, Mass.
PARSONS, CHARLES S. 908 City Hall Annex, Boston 9, Mass.
PRATT, DANIEL W. 33 Wildwood St., Winchester, Mass.
REYNOLDS, DAVID S., 1114 Lawrence Bldg., 149 Tremont St., Boston, Mass.
SANBORN, FRANK B. 104 Commonwealth Ave., Boston, Mass.
SCULLY, JOHN T. Board of Trade Bldg., Central Sq., Cambridge, Mass.
STACKPOLE, M. R. ..Care of Maine Water Power Commission, Augusta, Me.
YOUNG, ERVING M. 316 Huntington Ave., Room 332, Boston, Mass.

DEATHS.

GEORGE S. RICE December 7, 1920
EDWARD A. FREEMAN December 13, 1920

LIBRARY NOTES.

RECENT ADDITIONS TO THE LIBRARY.

U. S. Government Reports.

Manual of Design and Installation of Forest Service Water Spray Dry Kiln. L. V. Teesdale. Bulletin 884.

Mineral Resources of United States. 1916. Part. 1. Metals.

Report of Governor of Panama Canal. June 30, 1920.

Water Supply Papers, Nos. 448, 452, 454, 455, 457, 458, 472 and 490-A.

State Reports.

Massachusetts. Attorney-General's Report. 1906.

Massachusetts. Report of Commission of Waterways and Public Lands. 1918.

Massachusetts. Railroad and Railway Laws. 1909.

New York. Report of State Board of Health. 1918. 2 vols.

Ohio. Uses of Hydraulic Cement. Frank Harvey Eno. Bulletin No. 2.

Ohio. Manufacture of Hydraulic Cements. A. V. Bleininge. Bulletin No. 3.

Washington. Columbia Basin Irrigation Project. 1920.

Municipal Reports.

Brockton, Mass. Report of Board of Survey, 1919.

Hartford, Conn. Report of Board of Water Comm'rs. 1919.

Lowell, Mass. Report of Commissioners of Water Works. 1919.

Melrose, Mass. Report of Public Works Department. 1919.

New York, N. Y. Report of Bureau of Buildings. Manhattan. 1919.

New Orleans, La. Report of Sewerage and Water Board. 1919.

Plainfield, N. J. Annual City Report. 1919.

Miscellaneous.

Proceedings of National Association of Railroad Tie Producers. April 19.

Reports on Mosquitoes, by North Shore Improvement Association.

Story of Massachusetts Committee on Public Safety. Geo. H. Lyman.

The following are the gift of R. H. Stearns:

Mecanique Appliquée Hydraulique. A. Flamant.

Roorkee Hydraulic Experiments. A. Cummings. 3 vols.

Water Supply of England and Wales. C. E. De Rance.

Water Supply. Report of C. O. Johnson.

Water Purification. Percy Frankland.

LIBRARY COMMITTEE.

Vol. VII DECEMBER, 1920 No. 10

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PAPERS AND DISCUSSIONS

This Society is not responsible for any statement made or opinion expressed in its publications

WOOD AND CONCRETE PILING. — AN INFORMAL DISCUSSION.

By Charles R. Gow, James W. Rollins, Frank W. Hodgdon, Henry F. Bryant, Wright Taussig, John T. Scully, Frederick A. Waldron, and Harry E. Sawtell.

(Presented October 20, 1920.)

Charles R. Gow.* — Although this is intended primarily to be an experience meeting, it would still seem permissible to introduce as a basis of discussion some of the fundamental theories involved in piling practice.

Piling, when used, is expected to transmit the load which is applied at its top, down through underlying strata of unsuitable material to some more satisfactory layer of soil which is capable of carrying the given load safely.

If this latter stratum is composed of rock, or of material approximating rock in hardness, the piling becomes to all intents and purposes a series of wooden bearing columns supported against lateral displacement by the surrounding earth. In the usual case, however, the piles do not reach such a hard bottom, but for practical and economic reasons are stopped when their tips have penetrated a satisfactory distance into some natural deposit or combination of sand, gravel or clay of sufficient density to offer a considerable resistance to further driving. These piles cannot be considered as mere columns, because the soil immediately under their tips is incapable in itself of support-

* Charles R. Gow Co., 6 Beacon Street, Boston, Mass.

ing the entire load without greatly exceeding its bearing capacity. Such piles are known as friction piles because, in the process of driving, the surrounding soil is compressed and a resulting reaction set up which causes the earth to grip the exterior surface of the pile with such frictional intensity that the surrounding ground itself is stressed and the greater portion of the load transmitted to it.

The shape of the mass of soil so stressed by the pile is that of a surrounding elongated cone with the pile occupying its vertical axis, and the effect so far as support is concerned is the same as if the cone were a solid body with the load applied at its apex and uniformly distributed by its base upon the horizontal plane at the level of the pile tip. It will be seen, therefore, that such a pile will carry all the load that is capable of being supported on the area of distribution by the underlying soil. This area will vary as the cone base varies, and that dimension in turn depends upon the amount of frictional intensity of contact which exists between the outer pile surface and the adjacent soil.

A soft and easily compressible soil will offer much less frictional resistance than will a dense or compact material. Consequently in such a soil the pile must be driven to a greater depth in order to obtain the same area of distribution at the pile tip level which would obtain in the denser material.

Assuming, then, that a given load has to be carried by a certain cluster of piles, it is essential that the soil at the horizontal plane of the pile tips should be capable of supporting a uniformly distributed load of this amount. Otherwise settlement will result. Obviously, also, if there exists other material below this plane which is incapable of supporting such a load, failure must result, due to its yielding under the superimposed pressure.

A test load applied to a single pile sometimes gives misleading results because the cone of distribution may spread the load over a large area and thereby produce a low unit intensity of pressure upon the soil at the tip level. Unless the next adjacent pile is spaced at a sufficient distance from the first to prevent the two cone bases from overlapping, a double loading of the soil will result on the area occupied jointly, and the material may possibly be overloaded.

Under the most favorable conditions it is not desirable to drive adjacent piles closer than two feet on center, because the pressure cones are almost sure to intersect one another. Such a spacing allows 4 sq. ft. of horizontal area at the tip level upon which to distribute the load carried by the pile. As the soil decreases in bearing capacity, the spacing should be increased so as to allow a larger area of distribution for each pile.

Taking up now the practical side of the question, there may be mentioned several features not usually treated by textbooks on the subject, which are of more or less importance.

The question of whether or not piles can be successfully driven through certain classes of soils is one upon which there is much disagreement. In an experience covering several years, during which the speaker has had occasion to excavate to considerable depth in various sections of this locality, he has been impressed with the great number of instances where broken or damaged piles have been uncovered. Especially has this condition been noticeable in those districts where there exist considerable deposits of coarse gravel filling, through which the piles must penetrate in order to reach the natural underlying soils. Take for example the section known as the Park Square railroad property. This area was formerly a portion of the Back Bay marshes. The flats were reclaimed by depositing over them gravel filling to a depth of from 15 to 18 ft. The original surface was of mud extending to a depth of from 15 or 18 ft. more, and was underlaid with a natural deposit of blue clay into which piling must be driven in order to obtain a satisfactory bearing. The gravel filling has been thoroughly consolidated, so that it would probably offer a satisfactory resistance against settlement under ordinary conditions of loading were it not for the existence of the silt below it which renders the use of some form of piling absolutely necessary. To penetrate the silt a pile must first be driven through this upper layer of coarse gravel, where great difficulty is encountered.

Observation of many piles uncovered in this general locality indicates that a very large proportion of the piles fail to penetrate this gravel stratum. Apparently, the pile tip as it advances through the gravel carries ahead of it a large number of stones

and pebbles which ultimately are gathered into an enlarged mass, preventing further penetration. Further driving usually results in some form of damage to the piles. Sometimes the tip is broomed and mushroomed into a mass of crushed fiber; again the pile may fail by diagonal shear or by telescoping one part upon another; frequently these piles are found with their lower portions broken off and deflected laterally almost at right angles.

In one case, in which the speaker encountered difficulty in driving piles through this material, the trouble was overcome by sharpening the pile tips almost to a point, so that the several stones encountered would be deflected to one side and not carried down in advance as in the case of the ordinary tip.

There are many authorities who claim that wooden piles can be successfully driven through stone rip-rap. The speaker has uncovered a number of piles in his experience which have been driven into rip-rap but never has he found one which has penetrated such material for any considerable depth. In such cases the tips of the piles are soon deflected in one direction or another, as they encounter the inclined surface of the stones constituting the rip-rap, with the result that they become broken and broomed into a mass of pulp. It is probably true that such piles obtain a sufficient hold by means of this brooming so as to maintain them in place, but if there is unsuitable foundation material under the rip-rap the piles will be of no assistance in overcoming its effects.

A very common cause of failure on the part of piling to carry its load is the stopping of the piles before good bottom is reached. In many instances such piles develop apparent resistances to further driving due to the high frictional units developed in some of the upper layers of soil penetrated. This may easily lead to the assumption that the pile has brought up in good soil, when as a matter of fact the tip still remains in poor material. Under such circumstances the load applied to the pile is transmitted to the layer of filling possessing the high frictional value and is further distributed by this stratum on to the soft underlying soil which slowly yields under the pressure, causing ultimate settlement of the structure.

There is a mistaken notion on the part of many people that

an otherwise poor soil is rendered capable of supporting permanent loads by merely driving piles into it. It should be understood, however, that it is the penetration of the pile into good material which gives it its supporting power.

When the pile tip brings up in a sandy or gravelly soil there is usually no difficulty in securing the necessary resistance required to carry the load safely. When, however, the supporting medium is of clay, there is often some question as to when it is safe to stop driving. Clays are usually of a plastic nature, and generally speaking are apt to be stiffer when first encountered than at a greater depth. It is usually possible to drive piles into clay to any desired distance with little variation in penetrations under successive blows. It is also commonly found in this locality that in attempting to apply the *Engineering News* formula to such cases, they frequently do not give satisfactory results. If, however, the pile is permitted to remain undisturbed for a few hours, it will require several additional blows to produce again the original penetration, and if the formula is applied to these re-driving results very high load values will usually be obtained. In explanation of this phenomenon it may be said that during the original driving a rough and irregularly shaped hole is made in the clay by the projecting surfaces of the pile. As soon as driving ceases, the clay closes in around the pile, completely filling each depression and crevice, and gripping the pile surface so firmly as to offer an enormous resistance to further penetration.

During the construction of a pile wharf at the Boston Army Supply Base, some long piles were found extremely deficient in carrying power by the usual application of the driving formula. One 40-ft. pile when driven to grade gave a 10-in. penetration, indicating a safe carrying capacity of only 4 tons, whereas it was designed to carry 15 tons. A test load applied to this pile showed no settlement at 12 tons and only a slight settlement at 18 tons. The 12-ton load was adopted, and has since been carried without any indication of overloading.

Similar conditions were encountered in driving foundation piling for the wet slips of the Victory Destroyer Plant at Squantum. Piles which gave values of not more than 2 to 3 tons by

application of *Engineering News* formula subsequently supported test loads of 10 to 12 tons without appreciable settlement.

A more recent example of similar behavior of piling driven into soft clay was noted in connection with the pile-driving operation at the new John Hancock Building in the Back Bay district. In this case many piles gave initial penetration values for last blows of from 5 to 7 ins., whereas re-driving tests after a set of twenty-four hours reduced these figures to from $\frac{1}{8}$ to $\frac{3}{4}$ in.

All of the instances cited show that the usual driving formula is very conservative when applied to the soft clays of this locality. Of course the greater the depth of embedment which a pile has in such clays, the more certain one may be as to its sufficiency.

Vibration may often be an aid to the settlement of piles, and its effects should be guarded against. When structures are subject to vibratory forces the impulses may readily be transmitted to supporting piles, and in such cases piling which has successfully carried its designed static load may yield under the influence of the vibrations which tend to disturb and alter the condition of the soil immediately adjacent to the piles. Under such circumstances, deeper penetration and lighter loading are indicated as probably desirable.

The splicing of piles where extremely long sticks are required is often necessary or desirable. The joint between the sections may be secured by a variety of methods. An ordinary carpenter's splice, when the ends are halved into one another and bolted, probably gives the strongest and also the most expensive splice. A simple metal sleeve if of sufficient length and thickness is also effective. Oftentimes the two ends are butted together and spliced with outside cleats, just as splints might be applied. In some cases no other precautions are taken than to dowel the two ends together, using the top section as a follower to drive the advance section.

If the spliced pile is driven in a perfectly straight line and the soil is such as to introduce no deflecting forces, such piling can usually be successfully driven, regardless of the type of splice used. If, however, the driving is difficult and there are tendencies which cause the pile to deviate from a straight line during

the process of driving, the splice must be as strong as the balance of the pile or failure at this point is likely to result.

When long piles are driven in very soft material, and additional resistance is required beyond that developed, the result may usually be accomplished by lagging the pile vertically with 2-in. by 4-in. or 4-in. by 6-in. strips bolted to it. This serves to increase the surface exposed to frictional contact with the soil and likewise produces added compression in the surrounding soil because of the greater displacement.

Sometimes it becomes necessary to drive piles through water in locations where the bottom is difficult to penetrate. Such piles may be rendered stable by depositing rip-rap around them. In other similar cases it may be desirable to remove the hard material by dredging and to backfill the space after the piles have been driven.

The use of a follower in driving piles is not always deemed satisfactory, but there are many cases where its use may be beneficial. In driving into clay or plastic soils, it is usually possible to bring the pile heads to any desired elevation, because in such soils the resistance seldom reaches the point of absolute refusal. A follower may sometimes be used in such cases, allowing the pile to be driven from the original surface and its head stopped at the desired grade, eliminating the cutting of the piles and permitting the pile driving to proceed the excavation. This method was successfully adopted some years ago during the construction of the Metropolitan High Level Sewer at Hough's Neck, Quincy. The same piling contractor later drove foundation piling for a section of sewer in Chelsea, the driving being followed down through a considerable depth of silt which closed in and filled the hole after the follower was withdrawn. A compressed air tunnel was subsequently driven over these piles, and a masonry sewer constructed, for which the piles served the purpose of a foundation.

James W. Rollins.* — Colonel Gow has most thoroughly discussed the theory of pile driving, and therefore I shall limit myself to a practical talk based on our experience in driving many thousand piles under almost every possible condition.

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Most engineers want to drive piles to meet some favored formulæ — none of which in my judgment is based on any practical theory, nor do I think any reliable formula can be made. The conditions under which piles are driven vary so, that no reliable formula can be deduced from the results.

For instance, some clays offer but little resistance to driving, but after twenty-four or thirty-six hours develop perfectly satisfactory "set." Other clays, apparently of the same consistency, do not develop any "set."

A 6-in. tip small pile can be driven through stiff clay, while a heavy 8-in. tip pile is driven with difficulty, and as most requirements are as to lengths, great confusion, expense and delay is occasioned by the demand of an inspector for an average 1-in. penetration for the last five blows.

Again, gravel or sand offers great resistance and often impenetrability to piles, and figures according to the formulæ good for tremendous loads, but if driven in water for a railroad trestle the vibration of the pile will cause a jetting action and the piles may settle.

I think I can say conservatively that we have driven many more piles which would not, as compared with those that would, meet the conditions of any formula at the time of driving.

In most clays a final penetration of 4 ins. to 6 ins. is about all that can practically be obtained. The writer saw many piles driven in the South Bay district of Boston which would go two feet or more under the last blow, but never knew of any trouble on account of settlement, unless, as in the Back Bay and Charles River district, the whole country settled.

There are some conditions under which piles are driven which may, in the opinion of the writer, make trouble; for instance, in driving through gravel strata, over 3 or 4 ft. thick, into a soft stratum, which again overlies a hard stratum.

Such a condition existed at Cambridge Bridge, where the bottom was clay, 8 ft. of gravel, more clay, and again gravel, into which it was necessary to drive the piles. We got into difficulty right off, though we used selected, straight, heavy sticks, and shod them with cast-iron points (no good, by the way). After a few piles had been driven it became impossible

to get many of the piles through the gravel, and those that did go through went with such difficulty that we never knew where the point was, though the head went down. Finally the engineers adopted the only safe way in a condition like this and dredged the gravel out, drove the piles, then put the gravel back. Engineers and inspectors often do not realize that though the head of a pile is going all right the tip may be in shreds, or broken off; and softwood piles will not stand heavy hammering.

Water jets are used with success in driving piles through sand, and to some extent through gravel, but in the latter case a powerful jet with a great volume of water must be used to get satisfactory results.

Steam hammers have been developed, and with some success, but our experience with them has not been satisfactory, except in the use of the old "Vulcan hammer," which is not steam driven, but only raised by steam and dropped. The regular steam hammers will not stand up under heavy driving, and the consequent wear of the iron ram against an iron plate, and it is either necessary to have two or three hammers at hand or lose much time in waiting for repairs. They do good work particularly in hard driving in sand, gravel and stiff clay.

In the last few years steel sheeting has been extensively used, and can best be driven with a steam hammer. To pull this sheeting a steam hammer is used in "*reverse*" with great success.

To drive piles under water various devices have been used. One consists in driving a pile through a spout of iron, lowering the spout to the bottom and having the hammer work through it. Another consists of extension leads, with a follower guided in these leads, the bottom end of the pile being held in the lower end of the leads with two "knives," which sink into the wood as the pile is driven, while the top of the pile is in a hollow casting on the end of the follower. We have driven many piles 40 ft. under the water level with such a machine, with great success.

As to cost of pile driving, a good machine with crew is worth to-day about $100.00 a day. An average day's work is about 25 piles; making cost of driving alone about $4.00 a stick. We have driven 230 piles in a little less than ten hours, and 120 piles in

four hours; the latter work for a conduit in Charles River Basin.

When long piles are required, either yellow pine or Oregon fir may be used, even up to 100 ft. in length, or piles may be spliced. Some engineers splice piles by driving the first length, sawing it off, putting a $1\frac{1}{2}$-in. dowel 18 ins. long, 9 ins. into each length, then putting a splice pipe about 24 ins. long over the joint, driving the top section of the pile into the splice. Another way is to use four pieces of lagging 4 ins. by 6 ins., 15 ft. long, bolted through the piles at joint. When piles drive easy, much increased holding power can be obtained by lagging the piles as just described. This method is used extensively in pier construction in New York Harbor.

In clay driving, suitable allowance (not less than 2 ft.) should be made for the displacement of the clay by the piles, and the consequent " raising " of the bottom.

A dangerous condition may develop, especially on masonry or other structures subject to a lateral thrust, when piles are driven through a very soft bottom on to a hard bottom. Piles in this case have no lateral stability, and this stability should be maintained by dredging out some of the soft material, driving the piles, and then filling up to plan level with crushed stone or fine rip-rap.

In water subject to the action of " teredo," great care must be taken to protect the piles, completely covering the piles with gravel and sand filling.

The writer cannot agree with the proposition that ordinary foundation piles can be driven through rip-rap; as the results of driving through gravel and subsequent excavation, exposing the pile tips, show broomed, broken, and shredded piles, it seems incredible that any attempt to drive through rip-rap would not meet with a more general destruction of the pile tip.

Do not think, when a pile reacts from the blow of a hammer, which in the writer's opinion means a crippled pile, that because the head goes down, the tip is also going down in *good condition.* Many failures result from overdriving and consequent crippling of piles.

Having criticized all formulæ, it is pertinent to suggest some safeguard, and the only one the writer can suggest is, in ques-

tionable driving, where a 40-ft. pile or a 75-ft. will not bring up, that a period of "set" be allowed — forty-eight hours — and a new test made, and the result of the first two blows observed. If a set is obtained, all is well. If no set is found, additional piles or larger ones must be driven. But there is a safeguard in the fact that *age* will give strength — and seldom is a pile subjected to its ultimate load until many days after driving.

FRANK W. HODGDON.* — I will give you a little of my experience with actual pile driving. My first experience in pile driving was to make a contract to build a pile wharf. I never had seen a pile driver in use and had to study about the matter. That was in 1878. The pile drivers used what were very light hammers comparatively, and they used nippers to catch the hammer to be raised to the top of the gins, and there a man broke the hold of the nippers and let the hammer come down with full force. Those light hammers working on heavy piles would be run up to the top of the gins and then allowed to come down with full force, with the result that many of the piles would be split. Later the present scheme was adopted of attaching a rope directly to the hammer and using a friction clutch so as to let the hammer when it dropped unreel a drum and use a shorter blow, so as not to break the pile. The heavier the hammer used the better it is for pile driving. Mr. Rollins has stated that on some of our work he pushed the piles right down to grade or perhaps hit them once. At the time we started that work an ordinary pile driver had been in use on same job, and with this apparatus penetration of about 15 ft. in clay was obtained. The inspector called up our office and said there was no bottom; that the pile was going down at one blow. We asked the weight of the hammer, found that it was eleven tons, and told him that if it is stopping an 11-ton hammer surely it will hold up 10 tons, which is all we expect the pile to do. We had some that didn't go quite down, and we let a pile stand over night and then put on the drop hammer. The set had begun and it took a number of blows to start the pile. With regard to the question of set in the clay, you can get a good idea from this experience. We

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drive a good many wooden bulkheads, piles being 6 ft. apart. The mud that the pile goes into is this same clay which, after it has been dredged, dumped, and rehandled is pretty fluid and will run out on a slope of from 12 to 25 horizontal to 1 vertical. There is a good deal of almost fluid pressure against these bulkheads which pushes the vertical piles back on to the spur piles. We had a great many bulkheads fail in this way. In this particular place the original section of bulkhead had been built more than a year previously to the time it was filled. A gap had been left in the bulkhead to allow scows to float in and out, and it was closed up about a year later than the time the original section, with the same workmanship as the original bulkhead. In the gaps some of the main piles pulled up, but in the original bulkhead they all stayed down and the bulkhead stood. It was simply that those piles in the original bulkhead had been down long enough for the piles to bed in the clay and become thoroughly set. We figure, as a rule, to get piles down about 15 ft. in ordinary clay. Ordinarily clay varies to a considerable extent, and a little less than 15 ft. would probably be sufficient for an ordinary building pile, but for a bulkhead pile the spur piles should be driven perhaps 10 ft. and the main piles 5 ft. more, in order to get a grip in the clay. Due to this grip on the piles the foundation gets better and better every year. We have a great many cases where it is desired to withdraw piles to get them out of the way, and they can't be started until the grip is broken by striking them with a hammer.

Another use for piles is for compressing the material. We had a case where we had a sea wall built on clay. The load behind it was so heavy that it began to move. We found that the trouble was due to a soft spot in the clay, and that the wall was settling into it and moving out. To stop it we took the pile driver and drove piles down in front of the wall where the bottom of the dock was about 25 ft. below low water. We drove a row of piles about 4 ft. in front of the toe of the wall. They went down very easily. Some went 30 or 40 ft. below the bottom of the dock. Then we drove another row inside between the toe of the wall and the first row, and it took heavy driving. That was simply because the material had been compacted by

the first row, and the second row shoved in gave support to the toe of the wall. In the matter of securing support in very soft material, clay or silt, I might mention a case at East Boston where the contractor used the longest piles available and where they apparently went down full depth, but it was in a material so soft that we were practically sure they would settle when loaded. So we took 6-in. square timber about 20 ft. long and put it on the end of a 60-ft. pile; took strips 4 ins. by 6 ins., 20 ft. long, and bolted them on four sides of the piles; drove these 80-ft. spliced piles down and got very good results. All this lagging, bolts and all, was driven down below the bottom of the dock, so that the whole thing was buried in the supporting earth. They were held together thoroughly. There was no chance for them to slip off of the dowell, as Colonel Gow suggested has happened in several cases.

Speaking of the supporting power of piles, one contractor on the very first job I ever did told me he was building a bridge for the old Eastern Railroad, just over the line in Maine. On account of a soft bottom the longest piles the railroad could obtain anywhere were used. He said that at the last blow of the hammer they went down 2 ft., and he reported back to the superintendent, who said, "We've got to drive them as they are the longest we can get." This contractor said he made a pilgrimage to that bridge once a year for over five years, and that there had been no settlement. The formula would probably not have allowed much load on it. Yet a railroad went over it, and it was an ordinary pile trestle bridge.

I have had very little experience with rip-rap. I had to drive piles into it to support a portion of a pile platform in front of a wall. The rip-rap, which varied in depth from 12 to 20 ft., was mostly granite quarry or stoneyard chips, not very large and dumped from a scow. We started driving in that, although we didn't care to drive really through it. The rip-rap was put on top of the clay and spread the load on that clay. That would carry the wharf, but every pile went down. They went pretty crooked at times. They stood all kinds of ways, but they were limber enough to come up into place again. One of them didn't go at all. We finally simply sharpened it to a sharp wedge, put on a piece of iron in the shape of a V spiked on to the end. It

didn't go straight but wiggled down in between the stones. The wharf built on these piles has been in use forty years without renewing the piles. Driving sheet piling is another art. It works all right in soft material but, if any rocky or hard material is met, one can almost always count on its twisting and throwing the sheeting out. Into our clay you can drive four or five feet, enough to build any bulkhead or cofferdam without trouble, but you ought not to try to drive any depth, because you are sure to break the piles and put them out of business.

Henry F. Bryant.* — The theory of pile driving, as expressed in existing formulæ, does not seem to be very much in favor to-night. Nevertheless, I am going to give you a simple formula of my own. We all agree, I think, that the *Engineering News* formula is as good as, perhaps better than, any, but not of universal use.

In cases where you can start driving in or near soft material and drive through this some distance into sand, light gravel or firm clay, that formula gives good and safe results. Where the supporting stratum is soft and easily penetrated for considerable depths, the formula fails to indicate a reasonable fraction of the actual capacity shown by tests. Similarly, resting piles on rock or impenetrable earth strata may give a bearing value by formula much in excess of actual.

Mr. Gow mentioned the danger of leaving the pile tip on the surface of hard bottom, particularly when the upper portions are in fill or hard earth overlying soft material. In such cases the driving friction in the top layer plus the end bearing may compute safe according to the formula, whereas such a pile is certain to fail long before one with much greater penetration under the last blow, which has no firm top crust to seize the pile and add its great weight to it as the soft layer shrinks. I think the *Engineering News* formula, or any other which depends on penetration in such cases, is utterly useless.

Now, my contribution of theory is simply this: in cases of ordinary spruce, loblolly or other similar piles driven into bearing soil which can be safely penetrated, provide one lineal foot of penetration into such soil for each ton of load which the top of that pile is to carry.

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This, of course, excludes piles resting in liquid clays or silts which do not appreciably " set " on the pile after it is driven.

The basis of this rule is that side friction rather than tip bearing is the effective supporting agent. Pulling tests of piles have shown a yield point of about 2 000 lbs. per square foot of embedded surface, and, adopting one half this as the safe working figure, we have for an 8-ins. pile, neglecting the tip, a surface per lineal foot of approximately 2 sq. ft., which at 1 000 lbs. per sq. ft. gives us our 1-ton capacity.

Tests and many years' experience show this rule to be reliable.

In the case of larger piles, such as the 16-in. cast-in-place concrete piles, the theory holds equally well, giving a capacity of 2 tons per lin. ft. of penetration.

I think Colonel Gow will remember some concrete piles recently driven where we sought a carrying capacity of 30 tons with a penetration of 15 ft. into sand bottom. A test by the City Building Department developed a yield point of 55 tons under the code, which is reasonably close to our theory.

I would mention another feature about the use of the *Engineering News* formula, or any other which involves the factors of hammer blow and penetration. In using this formula, you may get an apparent final penetration when driving in hard material — let us say of $\frac{1}{2}$ in. If you go away twenty-four hours, you will find on your return that the pile has apparently come up. This I believe is due to compression in driving. Possibly some is due to brooming, and the broomed fiber straightens out somewhat. In testing piles under static loads, I have seen spruce piles compress in the same way.

Mr. Gow speaks of the earth loading on top of the piles in Park Square. In that locality, some of the piles have been well driven, not overdriven; nevertheless, they have gone down. Perhaps some of the Subway engineers here know about this. These piles, in some cases at least, have settled slightly, and in my judgement this settlement is due solely to the superimposed load of filling which is so hard to penetrate or follow through.

In splicing piles I do not like to take chances, and that is what I think one does if one uses simple center dowels as the

sole splice. I do not know that I ever remember seeing piles of any length driven on a dowel that didn't separate before reaching bottom. I may be wrong, but I recommend and use a pipe ring or collar 12 to 24 ins. long, placed over the head of one pile and receiving the tip of another pile put in it. I have just driven some 80 ft. piles that way and have stood some heavy buildings on them in very soft material. I have never found reason to fear any weakness except that from lateral pressure, and that is quite remote.

JOHN T. SCULLY.* — I have had some years' experience in the driving of wood piles, and I have noticed many times the brooming of piles. Often a young engineer has insisted on driving, in order to arrive at the penetration which the specifications called for, while in my judgment the pile was being broomed. I have seen many piles pulled up after such driving and found the point of the piles to be battered and broomed.

About driving through rip-rap, — there is great uncertainty as to the value of the wood pile after it has been driven into or through rip-rap. I have pointed the piles and found it as satisfactory as using steel shoes in penetrating a gravel or rip-rap stratum. The wood pile does not seem to me to be the proper pile to drive in such a case.

I think, Mr. Chairman, we ought not to limit our discussion altogether to wood piles. I have particular reason for saying this because I am interested in a concrete pile. Colonel Gow spoke of the hard stratum, or gravel, or compact sand through which it is almost impossible to drive a wood pile. I have found that, with MacArthur pile apparatus, it is possible to drive the steel pipe and plunger through a very stiff stratum of gravel or sand. If it is impossible to drive the plunger and tube through a layer of rip-rap or gravel, the plunger is removed and a batch of concrete is put into the tube. The plunger is then lowered into the tube and the steam hammer pounds on the plunger which forces the concrete at the bottom of the tube into the spaces in the rip-rap or gravel. The hammer and the plunger weigh about 5 tons, so you can imagine that there must be a fairly good concrete base at the bottom of the tube. After the

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bulb or footing is made, the plunger is again removed and the tube filled with concrete; the plunger is then put on top of the column of concrete and allowed to settle as the tube is withdrawn. This operation forces the concrete into any voids that may be left after the shell is removed.

It is sometimes argued that, if a pile reached a proper bearing stratum, a bulb or pedestal would not be necessary. It is not uncommon, however, to find it impossible to reach the stratum intended. In this case it seems to me very desirable to force this concrete into the soil.

HARRY E. SAWTELL.* — There seems to be a great deal of harmony of opinions in regard to the limitations of the *Engineering News* formula. I have one or two notes along the same lines which I wish to add to what has already been said.

It seems to me that the use of the formula should be limited to conditions where the material is of uniform consistency, and neither very hard nor very soft, such as stiff clay or loose, fine water-filled sand.

Our load tests seem to indicate that when those conditions obtain, it is proper to use the *Engineering News* formula at its value.

There are, however, many things which seem to modify it distinctly. For instance, the size of the particles composing the material into or through which the piles are being driven; the character of the fill or other material through which it is necessary to drive the piles in order to reach the desired stratum; the degree of compactness of the material, and degree of moisture. These are among the most important factors to consider.

We have made many driving and load tests on piles driven into what we call "medium clay," and where the embedments were of varying depths, and we have found that with about 18 ft. embedment, after the piles have set for, say, forty-eight hours, they will carry, without appreciable settlement, a load fully 50 per cent. greater than that indicated by the *Engineering News* formula at the time of driving. For greater embedments than 18 ft. the increase in load-carrying value is somewhat greater, that is, for medium clay. The increase in value for soft clay is

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much greater, due to the low value found during driving. Mr. Rollins and Colonel Gow have given you examples of that.

The *Engineering News* formula is, of course, a friction formula, and the frictional values of different soils vary greatly.

The best procedure, where piles are to be driven through various kinds of unsuitable material to a hard, suitable stratum, is to drive average-sized piles in different portions of the site through different typical soils, as shown by borings, driving them to various selected tonnages by *Engineering News* formula, then pull the piles and see if any damage has been done. You will thus have positive evidence as to just how hard the piles can be driven without hurting them and still have them well seated. Having this evidence, use the formula as a gage, and the piles can be driven with a reasonable degree of certainty with reference to their condition and proper seating.

Opinions differ as to what well seating is, owing to the varying kinds of soil. A true value of the load-carrying capacity of piles cannot be obtained except by load testing them. All jobs will not permit these tests to be made, but they should be made on all important foundation jobs where piles are necessary.

We have recently had an opportunity of making many tests of piles having practically point bearing. The piles had to penetrate material of various kinds, finally bringing up in a hard stratum on or in which we wished to support the loads. By driving and pulling piles and by re-driving and load tests, we found that a steam hammer, either 3 000 lbs. or 5 000 lbs., could drive hard-pine piles of about 12 ins butt and 7 ins. to 8 ins. tip, to a formula value of 25 tons, and a drop hammer to a value of about 20 tons, without injuring them. If soft woods are being driven, the safe values are 5 tons less than for hard woods. We then used the formula as a gage, and are getting a very satisfactory job of piling, feeling sure that the piles are well seated and that the percentage of injured piles is very small.

Under some conditions it is very easy to over-drive a pile and spoil it.

I have noted many times that engineers, inspectors, also pile-driver foremen who thought they knew all about pile driving, could not tell correctly whether piles after driving were good or bad.

Fortunately, we had an opportunity to load test and pull piles which had been pronounced good by inspectors and pile-driving foremen. We were driving spruce piles into a gravel bed. Everybody on the job knew that some were bad, but 50 per cent. were pronounced to be good. After load testing, we pulled them and found all but one badly broken and broomed.

They held up quite a load under test. Not as much as was designed, but quite a load; but as the load was increased there would be a rapid settlement. Then they held for awhile and began settling again. In fact, they performed bad stunts in settlement, due to brooming, sponging and packing of the gravel at points.

Another interesting thing we have observed is that it makes a great difference in results obtained if the driving block used in steam hammers is new or mashed up and spongy from long use.

The mashed-up block acts as an absorbant of the energy delivered by the falling ram. This reduces the penetration of the piles and increases the resulting tonnage. A change from an old block to a new one in one instance immediately reduced the value, according to formula, one half.

Some piles show a greater tendency to split than others. Red oak will split more readily than white oak, especially in cold weather when they are full of frost. This has been noted a number of times by our representatives; also, that in such cases drop hammers are harder on such piles than steam hammers.

It would be well to state here that we have found to be true the statement that steam hammers can sometimes drive piles through hard material without injury, when drop hammers cannot. I do believe, however, that more accurate results can be obtained from the use of drop hammers than from steam hammers, especially in pile testing.

I have had an opportunity of re-driving a large number of piles and of comparing their new value with that obtained at first driving, and I have also had these piles loaded, especially those in medium clay, and we find that the actual safe loads, according to load tests, do not correspond either to the original or re-driving formula value.

Generally, the first blows of re-driving will give a very high value, but afterward, as a rule, it comes back to the original values, or corresponds to it.

The load tests generally show that where the piles are embedded, in medium or soft clay, and the load placed upon the pile is greater than the working load, and it is allowed to stay on for a considerable length of time, that there is a slow but pretty sure settlement.

Where piles are driven through a fill or soft material superimposed on a hard stratum of very compact sand, as is often the case, and also drive through the compact sand, it will have a tendency to flow in a horizontal direction instead of upward or downward. This horizontal displacement will, in the case of cast-in-place piles, be very likely to pinch them in and reduce their cross-section.

On a recent job, we had occasion to load test some concrete piles of the cast-in-place type, Raymond piles, and the test acted very curiously. We decided to have the piles dug out, and found on doing so that we had by chance picked out and tested piles which had been badly pinched in, as I have described, and due to a thin stratum of very dense, hard sand through which the piles had been driven and which had simply been pushed to one side by the driving. Afterward a jet was used and no further trouble encountered.

Another interesting thing which has come under our observation in regard to concrete piles is a method of heating the concrete in the mixer during cold weather, and the results of that heating. The contractor used a kerosene torch which threw the flame right into the mixer. It was so designed and set that the flame did not reach the concrete but came very close to it, and it heated the air in the mixer to a high temperature. Not having seen this before, I thought I would find out what effect it had on the concrete.

I had 6 cylinders made 8 ins. by 16 ins. high and sent to the Massachusetts Institute of Technology. Three were of the hot material taken right from the discharge as it was put into the shells, and three were from material treated in the ordinary way to remove frost only. The 6 cylinders were crushed at the

end of twenty-eight days, and in every case the cylinders made from the material heated in the mixer by the gas flame as described showed a very marked reduction in crushing strength. The average reduction was 44 per cent. I don't know whether that has been the experience of anybody else or not. It is probably not safe to say that the results would always be the same. It would be interesting to try it out again. I hope somebody else will. I shall try it again when an opportunity offers.

J. Wright Taussig.* — You have heard a great deal, this evening, concerning the difficulties and uncertainties of driving wood piles. In many cases mentioned, wood piles have either broken in driving or been broomed at the point by over-driving, so that their ultimate supporting value is quite doubtful. Much difficulty has also been found in securing proper penetration with wood piles, and in knowing what safe value could be assigned to them after they had been placed.

Concrete piles were introduced to eliminate the uncertainties of the ordinary wood pile, and they have done more than this in many instances, since their use provides not only a safe foundation, but often an economical one. Some people seem to think that the use of concrete piles eliminates all difficulty or uncertainties, but we know this is not the case. Structurally they do satisfy most engineers' requirements, but the matter of loading must be carefully and intelligently investigated for each particular case. This requires an expert and experienced organization to install even the most perfect concrete pile.

Aside from pre-cast concrete piles, which have very limited possibilities, Raymond concrete piles are the type most widely known and used. In developing this pile, the Raymond Company has concentrated along two general lines:

First, to secure a concrete pile structurally perfect under any conditions.

Second, to acquire information and perfect its engineers in interpreting such information, so that adequate and economical foundations can be installed.

Structurally, the concrete pile molded in a steel shell, which

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is permanently left in the ground, answers all reasonable requirements for safety. Mr. Balsell has mentioned the fact that, where rocks or cemented hardpan exists in the ground, these hard bodies may be forced through the steel shell by the driving of adjacent piles. This we know is possible, since it would be economically impossible to use steel shells of sufficient strength to resist this unusual and peculiar condition. If hard material penetrates the shell, either before or after filling with concrete, it can either be seen from the surface or deduced from the fact that the concrete is forced out of the shell at the top. In either event, corrective measures, to secure a perfect pile, are taken.

The question of deciding on proper loading, and the interpretation of information secured on particular jobs, has received a great deal of attention and requires much further study before definite recommendations can be made. It is doubtful whether engineers will ever be able to formulate rules applicable to all conditions.

My feeling is that more information than is usually secured should be obtained before deciding on the foundations. Careful borings should be taken which, with other information available, may be used in forming conclusions. Too much care cannot be taken in interpreting this information, as soil of similar characteristics often gives entirely different results as far as pile loadings are concerned.

For instance, I have seen cases in which a pile has a final penetration of 1 ft. to the last blow, whereas on re-driving, after standing over night, only 1 in. will be secured to the last blow. Under similar soil conditions, I have seen piles driven which, after standing over night, secured the same penetration to the last blow as that secured the previous day.

In St. Louis, Raymond piles, driven 4 or 5 ins. to the last blow with a No. 1 Vulcan hammer, were driven further on succeeding days without appreciable increase on the final penetration. This would indicate a very low loading value, but six months after driving one of these piles was tested, under an actual load of 60 tons, with a total settlement of less than $\frac{1}{8}$ in.

It has also been found that piles which " tighten up " after

standing usually support greater loads than those which fail to show this characteristic. This is not always the case, however, and it is very difficult to determine what relation the second driving bears to the supporting value of the pile. In other words, the *Engineering News* formula is usually considered safe only when applied to the original driving.

The *Engineering News* formula is supposed to have a safety factor of 6. Actual tests made in a number of locations indicated that it has a safety factor of a least 2, but if the final penetration used in this formula is taken after the pile has set over night, there are grave doubts as to whether any safety factor is left in the formula.

The use of concrete piles in Boston is peculiar, in that you have soil here more or less firm near the surface, which is underlain by material susceptible of compression, — peat or bog, or whatever it is called. Any engineer knows that if you support a load in a material underlain by a compressible substance, you are apt to get settlement, so that whether wood piles, concrete piles, or short caissons are used, the load must either be carried through the compressible material, or distributed sufficiently to insure small and equal settlement.

Your conditions here in Boston require careful borings in most cases, and I strongly recommend that this practice be more universally adopted.

The question has been raised as to the practicability of driving piles through rip-rap. This would appear to be impracticable, except in rare instances. Where the rip-rap is not a comparatively thin layer and underlain by soft material, it is usually impossible to penetrate it with piles.

In New York it is quite customary to drive wood piles on the river piers through previously deposited rip-rap, which furnishes additional stability for the piles which penetrate very soft mud. Great care must be taken not to break wood piles, as it is very difficult to determine whether this is occurring.

In Kansas City, Raymond concrete piles were driven through 15 ft. of clean one-man stone, placed over very soft material. The stone was simply displaced and forced into the mud, as evidenced by the fact that, after some of the piles were driven, the surface of the stone in their vicinity had settled some 4 ft.

The engineers on this particular work did not think it possible to drive through the rip-rap, but the steal core was able to secure the results I had mentioned, and perfect piles were secured in the loose rock by leaving the steel shell in place.

My experience with the Raymond Company leads me to conclude that less than half the piles driven carry their load to a definite bearing stratum. In other words, in most cases piles support a load by distributing it more or less uniformly throughout their length to the adjacent soil. It is therefore particularly necessary to consider the bearing power of piles uniformly supported, and experience shows, as I have said before, that the *Engineering News* formula gives the best results for doing this.

Frederick A. Waldron.* — I take pleasure in placing before your Society a few facts relative to the investigation made, and the results obtained in connection with the pile foundations of the new home office building for the John Hancock Mutual Life Insurance Company.

This building is located on Clarendon Street and extends from Stuart to St. James Avenue, and is approximately 250 by 250 ft. It takes the form of a hollow square, with a center tower building of 10 stories in height, surrounded by a building 43 ft. wide, 4 stories high (designed for 10 stories), all having a ground floor and a basement.

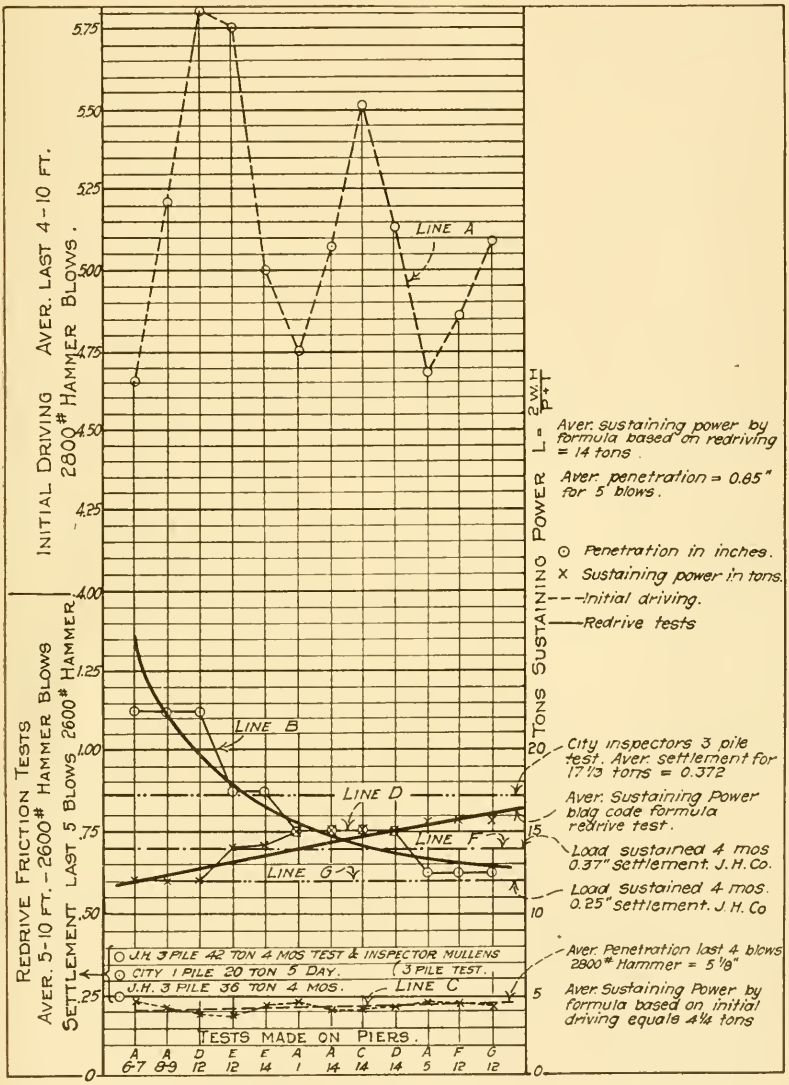
In order to determine the final design of foundations and pile loadings, the following method of procedure was adopted:

A. Borings were made by Guy C. Emerson, C.E., in the early part of 1919, followed later by additional borings made by the John F. Scully Company.

B. The result of these borings showed a bed of hard and medium clay varying in thickness from 17 to 20 ft. The top of this bed was practically level and parallel to the grade of fill, its average depth being about 22 ft. below the grade of the lot.

C. In January, 1919, 2 groups of test piles were driven, containing 3 piles each. The fill around these piles was excavated to the top of the slit and peat. These piles were loaded to 12 and 14 tons respectively, and observations were taken on their settlement for a period of from three to four months. In

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PILE PENETRATION, LOADING AND TEST DATA, JOHN HANCOCK MUTUAL LIFE] INSURANCE CO. NEW HOME OFFICE BUILDING.

order that ice and snow should have no effect on these piles, the pits around them were filled with salt so as to prevent freezing.

The results of the settlement of these tests is shown on the diagram attached herewith. This settlement took place at about seven days after the application of the load, and from that time to the end of the four months' period, readings were taken weekly, and no settlement occurred.

D. It was observed in the driving of these test piles a re-drive test, applied from twenty-four to forty-eight hours after the initial driving, showed a tightening up of the piles and a greatly increased resistance of the soil.

E. It was then decided to assume the load per pile as 12 tons, the maximum allowed by city law, knowing that the type and occupancy of the building would be 30 per cent. less than the maximum.

F. From the results of the test load and the borings, cross sections were developed for different rows of piers, and the length of pile for each pier, predetermined, were driven to these predetermined lengths, regardless of initial penetration.

G. Upon the beginning of actual driving of piles and the city inspection, it was found that the penetration after the fill had been removed entirely from the lot was such that, according to the strict interpretation of the law, a bearing power of less than eight tons was all that the law would allow, based on the average sinking of the pile at its initial driving.

This was so low that the burden of expense that fell upon the owner would be excessive and unreasonable.

H. Tests were therefore started by the city inspector, the results of which are shown on the accompanying diagram.

I. The situation which developed demanded a thorough and drastic investigation of what the subsoil and the piles under the actual conditions would be called upon to sustain, at the final loading of the structure, which resulted in the following method of procedure, the findings of which are plotted on the attached diagram, which is briefly described for convenience and ready reference, as follows:

Re-drive tests were made upon a number of different groups of piles, and their penetration recorded. These groups were

then plotted upon the diagram, beginning with the average maximum re-drive penetration (Line *B*). From records on these groups was plotted the amount of penetration at initial driving (Line *A*).

The sustaining power was calculated by the *Engineering News* formula for both initial (Line *C*) and re-drive penetration (Line *D*), and plotted on the diagram for both cases. The result of the time tests made by the owners and the result of the tests made by the city were then placed on the diagram (Lines *F* and *G*).

It is very interesting to note how closely the formula figures correspond with the sustaining loads allowed by the *Engineering News* formula when applied to the re-drive tests.

On the re-drive tests no increase in penetration was noted after ten blows of a 2 600-lb. hammer falling 8 to 10 ft.

Results. — From this evidence, and at the suggestion of the building commissioner, Wilson, an appeal was made for a load of 10 tons per pile on the building which was to be erected immediately to 10 stories, and 11 tons per pile on that portion of the building which was to be erected to 4 stories for the present and 10 stories later.

In view of the evidence submitted, the above loadings as applied for were fully allowed.

An interesting feature of the diagram shows there is apparently no relation between the sustaining power of a pile in the initial driving and re-driving test.

It also shows that a formula can come very close to the actual conditions if properly applied, and if the unknown quantities of a formula are determined by the engineer with a reasonable degree of certainty, that its results are coincident with the developed facts.

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